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MAINTENANCE ENGINEERING

IN PLANTS, MILLS, AND FACTORIES

HERETOFORE "INDUSTRIAL ENGINEERING"

WITH this issue "Maintenance Engineering" becomes the name of this publication. The purpose of the change in name is to express correctly the editorial objective, which is to serve the men responsible for the function of maintenance in industrial plants—to tell them what to do, how to do it, and what to do it with.

Since its founding, in 1882, as "Review of the Telephone and Telegraph," this publication has consistently formulated and discussed the problems involved in maintaining uninterrupted production. Only recently, however, and largely through the efforts of the publication itself, has the function of maintenance engineering attained the position of recognition and dignity to justify its standing alone, as it now does under the new name.

Formerly maintenance was thought of as repair. Today industry considers repair as a minor phase of maintenance. The function itself is recognized as involving the selection and installation of much of the mechanical and electrical equipment for industrial plants, the systematic inspection and servicing of all equipment to prevent breakdown, the inspection and care of buildings, responsibility for the arteries of communication, lighting and protection systems, and so on. As the function has broadened and recognition has grown, the responsibility of the reader has changed accordingly.

The editors predict for "Maintenance Engineering" a reception even more enthusiastic than that accorded under the old name, in itself a remarkable tribute.

A McGraw-Hill Publication

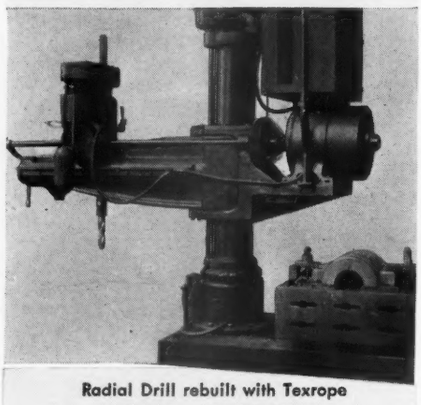
25 cents per copy

APRIL 1931

LOOKING FOR LOWER COSTS?
these facts from other men may help you

Here is a specific saving of over $12,000. Texrope Drives were installed on two radial drills. Motors were mounted on brackets, coupled thru Texropes, supplied with reversing controllers. Twelve gears, 14 bearings and one clutch were eliminated. Drilling speed increased. Piece work cost reduced from $6.75 to $3.00 . . . and the difference in cost between installing the Texropes and buying two new drills was $12,600.

In another plant a Texrope Drive replaced flat belts on a bevel gear cutter. Time saved on forgings averaged 42% . . . on bar stock, 67%.



Radial Drill rebuilt with Texrope Drives saved $12,600.

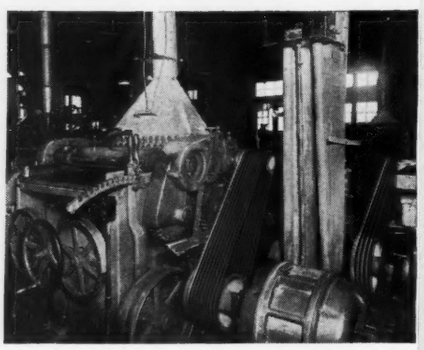
On an ice machine, in a large hotel, Texropes saved 10% in power alone . . . and a paper manufacturer tells us that "Texropes accomplish their work as nearly perfect as we believe is mechanically possible".

Next we hear from a manufacturer who installed Texropes five years ago . . . and reports that after this long period of steady service the original belts are still in use.

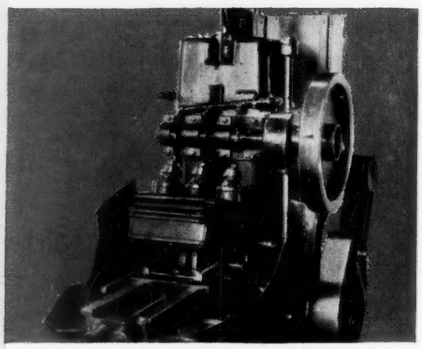
"It is simply impossible to overestimate the economy, efficiency and value of your Texrope Drive, compared with all other forms of driving power", says a well known manufacturer of bank and store furniture.

Can *you* afford *not* to investigate a drive that has effected economies for thousands of users? Over 100,000 Texrope Drives in use in all branches of industry . . . from ½ to 2000 H. P. . . . and wherever correctly applied they have always saved money. 98.9% efficient for the life of the drive . . . silent . . . slipless . . . shock-absorbing.

Let a Texrope engineer give you complete information. And send for a copy of bulletin 1228-K, showing over 70 Texrope applications.



25 H. P. Texrope on cabinet planer; 5 H. P. Drive on jointer.



Texropes on gear cutter averaged 42% saving of time.

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THE DRIVES THAT REVOLUTIONIZED TRANSMISSION PRACTICE • • •

MAINTENANCE ENGINEERING

A McGraw-Hill Publication, founded 1882

APRIL, 1931

THE forty-six following pages contain comprehensive abstracts of the papers to be presented at the three Maintenance Sessions of the National Industrial Congress in Cleveland, Ohio, on the 16th and 17th of this month. Thus these abstracts comprise the bulk of the editorial section, and fittingly so, because of their outstanding quality as contributions to the meager but growing store of literature devoted to Maintenance Engineering.

Gained from a study of these papers will be definite information concerning specific problems in maintenance. Gained, also, will be the knowledge that there is in industry a constantly increasing number of worthwhile men who are connecting themselves with the maintenance function; and that the recognition of the importance of the function, and therefore its standing, are growing at a remarkable rate.

If any one tendency is indicated by the papers to stand out as a leader, it is the tendency of industry to give a tremendous amount of thought to the possibilities of conducting the maintenance departments on a wage incentive basis. For a long time industry has secured the benefits from incentive payment for production. Opportunities for savings in production departments have by no means been exhausted, but they have been reduced, and now engineers are beginning to look at the other great function—maintenance—as offering a rich field for savings, accompanied by greater rewards to workers, when conducted according to definite plans paralleling those already proved in production departments.

The Maintenance Sessions constitute one part of the activities of the American Society of Mechanical Engineers in its participation in the National Industrial Congress. It is with the consent and co-operation of the Society that the abstracts are made available in this issue of *Maintenance Engineering*.

VARIATIONS IN MAINTENANCE COSTS AND PROCEDURE

E. V. STOODY and G. I. ROSS
Assistant to the President *Chief Engineer*
MacDonald Bros., Inc., Boston, Mass.

E. V. STOODY

G. I. ROSS

MAINTENANCE, as a function of plant operation, is often regarded by management as a necessary evil. Too frequently it is considered to be non-controllable and is permitted to function independently within what are regarded as reasonable limits of expense. These limits usually are determined by guess. Maintenance departments are enlarged for emergency maintenance, or for construction, and are allowed to operate with increased personnel long after the emergency work has been completed. On the other hand, due to the hazy conception of what maintenance costs should be, the maintenance department, in periods of economy, too often is depleted beyond justification and with eventual detriment to the company.

If two identical plants manufacturing the same product were placed side by side under unified executive direction, it is safe to assume that any inconsistencies in operation costs between the two plants would be quickly discovered. If the maintenance force in one plant were twice as large as that in the other, the management would soon take steps to determine the causes. The variation would warrant this attention and each plant would serve as a yardstick by which to measure the other. Yet this condition exists in more than 75 per cent of the plants which we are called to study and many of these plants enjoy the very best of managerial talent.

IF YOU have ever wondered whether every plant has as high maintenance costs as your own, you will be interested in these charts and data. They show the maintenance ratios in 20 typical plants; the wide dispersion of ratios indicates that there is a vast field for improvement in the general treatment of the maintenance problem.

True, the plants studied are not identical, nor are they side by side under unified direction—nor do they need be if studied carefully and the variables given due consideration.

This relatively large difference in maintenance ratios is illustrated by the accompanying charts. The twenty plants used for purposes of comparison are typical of the many studied. The grand total of the plant forces represented by the charts is 28,872 persons and the total of the maintenance forces is 1,797. There may be some difference of opinion regarding one or two of the groups selected as pertaining to the maintenance function, but such difference is bound to be slight and will not alter the general relation of the forces.

The variations in maintenance forces expressed as per cent of total employees may be explained by:

1. Different standards of plant maintenance.
2. Variations in the efficiencies of maintenance forces.
3. Physical differences in plants, equipment, processes.

Chart 1 shows the 20 plants arranged according to number of employees and indicates that in the group, size of plant alone has no bearing on the maintenance ratio. Chart 2 shows the same kind of comparison for the same twenty plants, the only difference being that janitors, sweepers, watchmen, and yardmen have been excluded.

In plants in which no maintenance employees are listed under any particular classification, the total absence of such classification can be explained by a variation in definition, the work is handled by employees classed as productive or, due to the nature and size of the plant, the work is so minor that it is handled by employees listed under other classifications. Consequently, in the discussion of any particular classification, such plants are not considered if the classification is totally absent.

The chart indicates that the greatest variations occur in the following order: Janitors, sweepers, porters; machinists, machine repairmen; yardmen; belt repairmen, oilers, millwrights; masons, plumbers, tinsmiths; watchmen. This is shown on Chart 3.

The wide variation in the Janitor-Sweeper group can be easily understood when it is considered how widely the opinions of management differ with respect to the cleanliness and tidiness of their plants and offices. Another factor which affects this classification is the type of industry. A factory with a large machining department requires the disposal of many turnings and chips which may be done by this force. The highest ratio in this

group is attained by a plant of 170 persons and is due to the fact that the plant is housed in an extremely poor group of buildings and that the maintenance force is poorly supervised.

This brings forth an important point, namely, that inherent property conditions may exact a heavy penalty from the company in the way of high maintenance charges. These would include not only such forces as sweepers and janitors, but also building repairmen, watchmen, etc. This consideration is something which may be accepted or equated against the capital cost of a change.

In Group E, Machinists and Machine Repairmen, the variation is undoubtedly due to a large extent to the disparity between repair requirements in different industries and to the policy in some companies of letting out major machine repair work to outside contractors.

In the case of the largest variation, Example No. 8, the maintenance force was found to operate very inefficiently and this fact, coupled with the character and age of the plant equipment, was conducive to a high force. The next largest ratio is found in the case of Example No. 14, where an excellent operating department was found to exist.

The plant in question, however, is highly mechanized and is inclined to run high on machine repair work.

Group L, Yardmen, is bound to be a large variable due to the difference in industries. Plants which have a considerable amount of loading and unloading of sheet metal often call upon the maintenance yard crew to perform this work. This is exactly the reason for the high ratios in Examples Nos. 16 and 21.

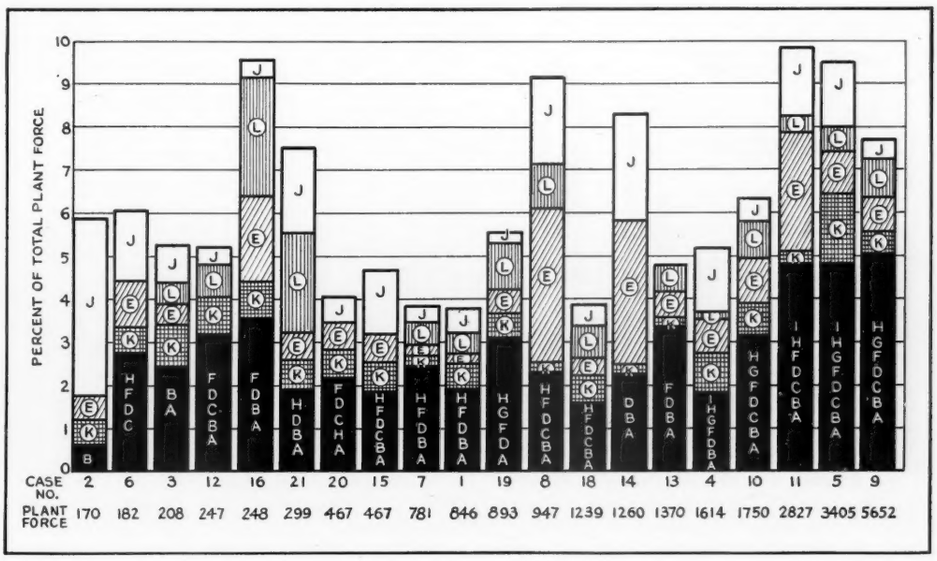
The variation in Group B, Belt Repairmen, Oilers and Millwrights, is not so readily explained. Of course there is a certain amount of dispersion due to a difference in the nature or condition of the plant equipment. Other variations will creep in due to the difference in definition of the trades in the various plants. In some plants the electricians take care of the motor oiling on their routine electrical inspection, while the millwright work may be done by machinists or carpenters. In this group the effectiveness of the force probably plays as large a part as any other cause.

The Masons, Plumbers, and Tinsmiths, Group H, seem to vary principally due to plant and equipment differences. Obviously, however, maintenance standards and the efficiency of the department play a large part. The highest ratio in the group of plants under consideration obtained this questionable honor due to all three causes

Chart 1—Ratio of maintenance to total plant forces in twenty typical plants arranged according to size of plant

LEGEND:

A—Supervision and Clerical
B—Belt Repairmen, Oilers, Millwrights
C—Blacksmiths and Welders
D—Electricians
E—Machinists, Machine Repairmen
F—Carpenters, Pattern Makers
G—Painters
H—Masons, Plumbers, Tinsmiths
I—Truck Repairmen
J—Janitors, Sweepers, Porters, Etc.
K—Watchmen
L—Yardmen



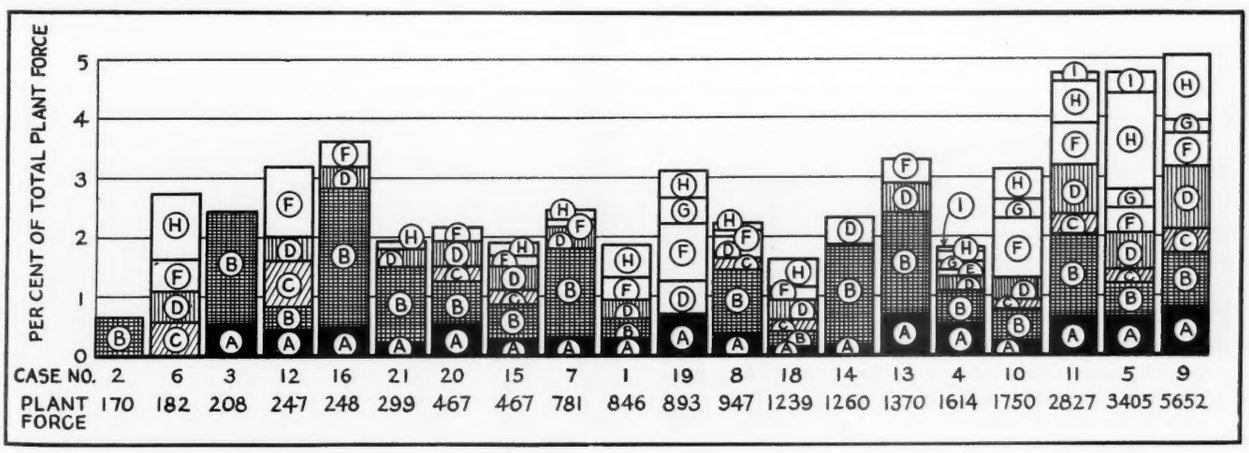


Chart 2—Ratio of maintenance to total plant forces—same as Chart 1, except that Janitors, Sweepers, Watchmen, and Yardmen have been excluded from maintenance forces.

but principally plant conditions and departmental efficiency. The plant is a large one carried over from the war period and is encumbered with many more buildings than are required. Operating at productive capacity, the ratio probably would have been lower.

In the Watchmen Group, K, the same plant, Case No. 5, had the highest ratio. This, again, is traceable to many buildings to be policed, many gates to be guarded, and street and railroad crossings to be watched.

Inefficiency in maintenance departments can be attributed largely to the following causes:

1. Poor or no supervision of operating force.
2. Poor physical arrangement of quarters.
3. The absence of adequate inspection routines and standards.
4. The absence of a suitable order routine for flagging expenditures before they are made.
5. Too many straw bosses.
6. Faulty organization, preventing an economic distribution of maintenance labor.

In many cases more than one of these causes is evident. Thus we find that scattered maintenance shops in outlying buildings often are conducive to operating inefficiencies due to the impossibility of good supervision. Likewise, the absence of adequate inspection routines is often accompanied by frequent and unexpected machine failures. This places the maintenance function in the "corrective" class rather than the "preventive" and thereby introduces sudden and disorganizing demands for specialized labor.

In addition, such a laxity often is responsible for interruptions in productive output.

High maintenance costs many times are charged to the inefficiency of the department when the real fault lies in the absence of suitable maintenance standards. This means that much of the work done may be unnecessary. It means that the standard of upkeep is decided by the individual worker and that the state of repair of both plant and equipment varies with the ideas of the individuals performing the repair work.

In busy times the general tendency is to slight "precautionary work" and in times of depression to overdo work of this nature.

The importance of plant maintenance cannot be emphasized too strongly, for it is the maintenance function that insures against interruption in production due to machinery breakdowns. A slight production tie-up may involve losses far greater than any maintenance cost. Furthermore, neglected equipment very often will wear out before its useful life has expired, thereby introducing hidden losses which ultimately will appear to the consternation of the management.

While maintenance must not be neglected, it must not be overdone, for the plant that maintains within practical limits will outstrip quickly its competitor that goes in for "frills and fancies," all other things being equal. In other words, there is a point at which an economic balance exists between maintenance effort and operating costs, and this point is different for each industry. The determination of this economic balance involves the setting of maintenance standards, which should be determined as carefully as product standards, for the maintaining thereof involves a definite charge against the operating income.

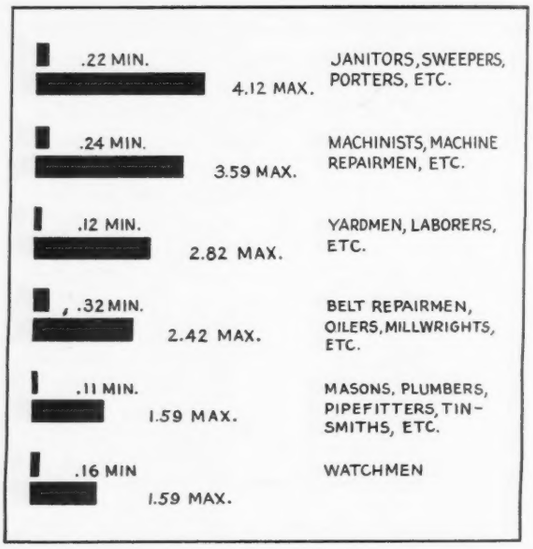


Chart 3—Graphical analysis of variations in the various classifications. Figures shown are percentages of the group to the total plant force. Zero percentages are not included.

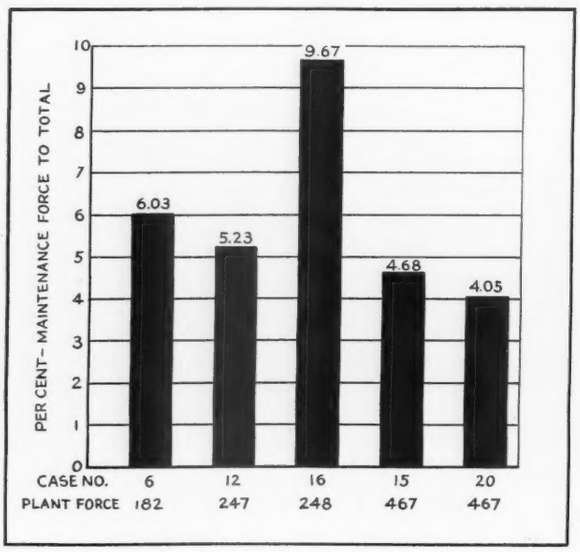


Chart 4—Relation of maintenance force to total plant force in five similar plants performing stamping and assembly work.

Because of the difference in standards, maintenance forces are not strictly comparable between plants, but if an unfavorable comparison is not interpreted to reflect inefficiency, it can be regarded to show an unwise difference in standards or an inherent penalty due to the condition of the plant property. The previous discussion of Chart 1 shows how variations from the average can be explained in an analysis of the maintenance ratio. This analysis can be made even more searching by segregating the plants according to type of equipment and the character of the product. For example, let us

examine a group of the same plants, engaged in making stampings and assembling them into complete units. The comparison is given in Chart 4.

The five plants listed in this classification are considered as being comparable from the viewpoint of similarity of manufacturing processes. It is interesting to note that plants Nos. 15 and 20, with the greatest number of employees, show the lowest maintenance ratios. Plant No. 16 has the highest ratio and when compared to the other plants listed in this class shows glaring inconsistencies. Reference to the chart indicates that in Plant No. 16, classifications E, L, and B are the most out of line. A study of the plant reveals that great quantities of sheet steel are handled in the yard, a factor that explains the excessive percentage in Class L, Yardmen. Further study fails to reveal any explanation for the excessive ratios in Class E, Machinists and Machine Repairmen, and in Class B, Belt Repairmen, Oilers, and Millwrights. Consequently, in considering a reduction in maintenance costs, it is reasonable to look to Class E and Class B.

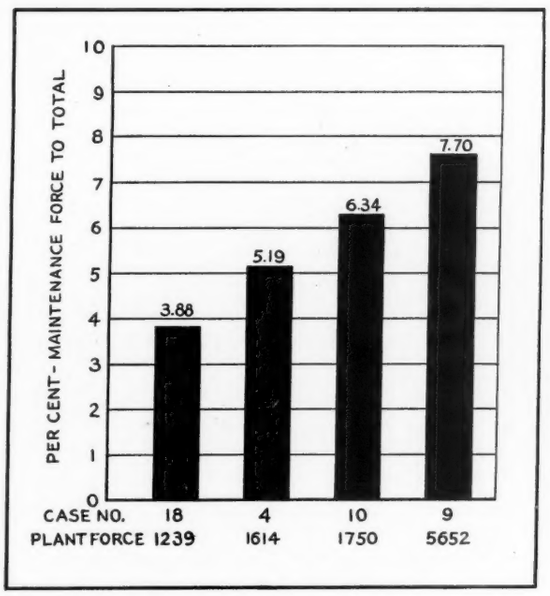


Chart 5—Relation of maintenance force to total plant force in five similar plants fabricating and finishing small copper-alloy parts.

Plant No. 6 also can be considered to be somewhat out of line. It employs the smallest number of employees and shows the second highest maintenance ratio. In this plant, Class J, Class E, and Class H show the greatest ratios of the total. Class J, Janitors, Sweepers, and Porters, can be explained by the fact that the management takes extreme pride in plant appearance and consequently the plant and grounds are maintained in excellent condition. Even so, the justification for this extra expense should be questioned. Class E and Class H, although apparently high, cannot logically be considered for reduction due to the size of the plant. Although as percentages they are high, when reduced to numbers of employees each shows less than two workmen.

Considering the opportunities for reduction that appear to be possible in Plant No. 16 and to a slight extent in Plant No. 6, and assuming that these reductions have been made, then the five plants in this industry classification become approximately equal from the viewpoint of maintenance ratio.

Another interesting comparison can be made of the four plants depicted on Chart 5, wherein the work consists in fabricating and finishing small copper-alloy parts. The four plants listed in this group are definitely comparable from the viewpoint of similarity of manufacturing processes and products, and also from the viewpoint of many old buildings housing the various manufacturing divisions. Reference to the chart fails to reveal any startling inconsistencies in any classification among the four plants listed in this grouping.

A detailed analysis of the maintenance departments in these four plants revealed that in Plants Nos. 4, 10, and 9, the maintenance departments were too decentralized and split up into too many sub-divisions. All of this resulted in an uneconomical distribution of maintenance labor. Reductions were possible in each of these three plants.

In conclusion, it can be said that maintenance costs are controllable. Standards can be determined and made to operate as effectively as production standards. Yardsticks are available for measuring the effectiveness of the plant maintenance department and, when applied intelligently, are of immeasurable benefit in controlling this function. Experience in numerous manufacturing plants throughout the country has proved these facts.

■

Variable-Speed Transmissions

D. W. CLEM

Reeves Pulley Company, Columbus, Ind.

(Presented at the Design Handling Equipment Session)

VARIABLE-SPEED control plays an important part in modern production. The need for speed regulation is determined by changes in operation, fluctuations in temperature, variation in quality of material, changes in shape or size of product, number of workmen available, differences in ability or skill of workmen, changes in construction of product, changes in the tension, shrinkage, stretch or consistency of material, changes in humidity, varying production schedules, exact synchronization of two machines or systems and changes in composition of material. These constantly changing factors demand an infinite number of adjustments of the materials-handling conveyors.

Synchronization does not always imply speeding up, for it can mean slowing down as well. The prime consideration is maximum quality production at least expense. Infinite-speed regulation reduces spoilage and makes possible uniform quality of product under varying conditions.

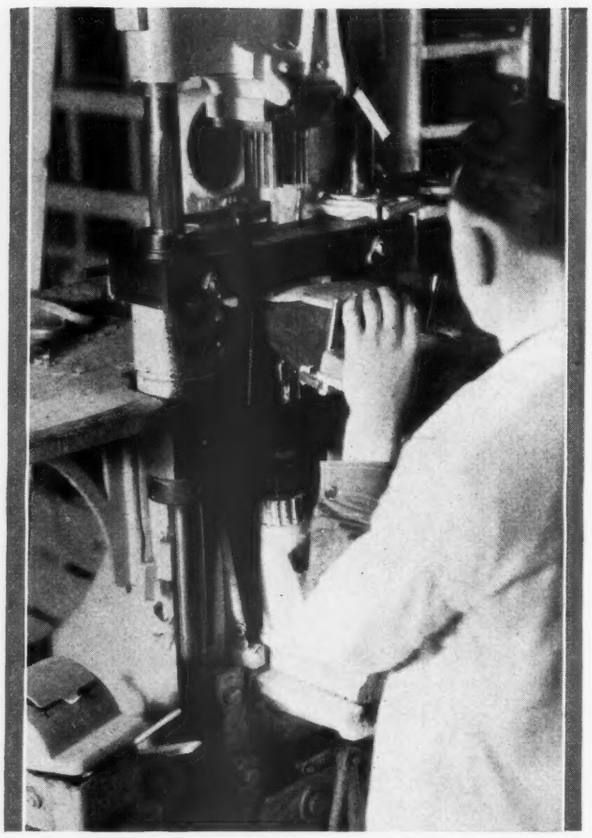
New designs of the mechanical variable-speed transmission include an electrical remote control, by means of which the speed may be regulated from one or more push-button stations; an automatic control providing entirely automatic speed regulation; an inclosed design for use in certain processes; a vertical transmission; and a special unit with frame to receive motor and speed reducer.

Paint as Maintenance, Paint as Production

T. J. MALONEY
New Jersey Zinc Company

AT THE maintenance session, in Chicago a year ago, you listened to Mr. Brandt, Assistant Works Manager of the Westinghouse plant at East Pittsburgh, talk on wage incentives in maintenance. At that time it seemed to me the interest in his utterances was unusual. So was his theme. Mr. Brandt has told me, with pardonable pride, that since then a majority of those present either visited him and made a personal inspection tour of the Westinghouse plant or wrote letters requesting further information on the system.

I think the subject worth continuation. By taking the painting set-up and showing what wage incentives have accomplished in all phases of plant painting, we can follow painting to a logical conclusion and show the fundamental set-up for other operations. In doing this, I am omitting any theoretical aspects of the problem, and limiting myself to facts and results as achieved by Mr. Brandt and Mr. Stegemarten of Westinghouse and Mr. Lowry of Procter and Gamble. Maintenance wage incentives may be just as advanced in plants with which I am unfamiliar, but I believe Westinghouse pioneered and proved the plan. At that time Mr. Lowry was associated with Mr. Brandt and Mr. Stegemarten at Westinghouse.



This machine is painted orange—the worker's own choice of color. Result—elimination of eyestrain, less fatigue, better morale, and increased production. The jacket, also orange, was bought at his own initiative and expense.

■

"I have been working here for over 25 years, but if I had to go back to the black machines we had a year ago I would pick up my kit and walk out."—An old sole fastener in a shoe factory.

One note on Mr. Lowry's work at Procter and Gamble is of particular importance. Instead of maintenance wage incentives being the natural conclusion of success in production time study and incentives, maintenance was the first problem tackled. Although this made a harder task at the start—for unquestionably incentives are more easily applied to routine production — its success meant but one thing, a full proof of its time and money saving possibilities for all departments. So much for what we might term production methods of painting plants. The other half of the paper is devoted to two outstanding examples of plant painting to assist production.

In visiting various plants throughout the country the personalities of the men you meet give an index to the whole industrial set-up. Again using paint as the definite example, the general superintendent, the works manager, and the vice-president in charge of production, as opposed to the plant engineer, think of and use paint differently.

Briefly, paint has certain humanitarian aspects (as have heat, light, ventilation and sanitation) which the superintendent wants to utilize for the benefit of the employee. The resultant better production and working conditions are his ultimate aim. The super-

intendent is close to materials, but closer to men. The plant engineer, on the other hand, finds paints, like belting, shafting, motors, etc., materials that must be applied, and the quality, application and time of application are of most importance to him. His job demands a reverse of the superintendent's—close to men, closer to materials. Though I may be wrong, this is my impression, not alone from observation, but from service under plant engineers in two large companies.

T. J. MALONEY

Paint, a maintenance material, has production assets. The two plants I consider most interesting from a painting standpoint among those I have visited in the last year, are both the results of careful consideration of working conditions best suited for the employees' health and happiness. Supporting the reasoning stated in the previous paragraph, the results achieved are due to detailed study by G. K. Simonds, vice-president and general manager of the Simonds Saw & Steel Company, and Arthur Donovan, president of the E. T. Wright Shoe Company. The Simonds plant, the present ultimate plant in experimentation, is now under construction. The Wright plant at Rockland is an old one. But the application of color to machinery and interiors has shown that this factor of paint color, an asset anywhere, can rejuvenate an old plant.

Maintenance Painting on Wage Incentive

Wage incentive is a device to measure and scientifically compensate for the labor energy consumed in manufacturing and maintenance operations. This means, also, analyzing and recording the essential elements of labor control.

Let's start right in on the technique of wage incentive, applied to maintenance painting. Dividing the successive steps into Analysis, Measurement, Compensation, and Control, we first analyze the department. It is neither more nor less than a common sense summary of your men, materials and problems in painting.

It divides itself into: 1. A tabulation and description of all the major painting operations and jobs.

2. The kinds, sources and chronological flow of materials through the department. Also a brief description of the mechanical equipment: Scaffolding, paint mixers, jigs, etc.

3. The organization of the department—in other words, estimate of men.

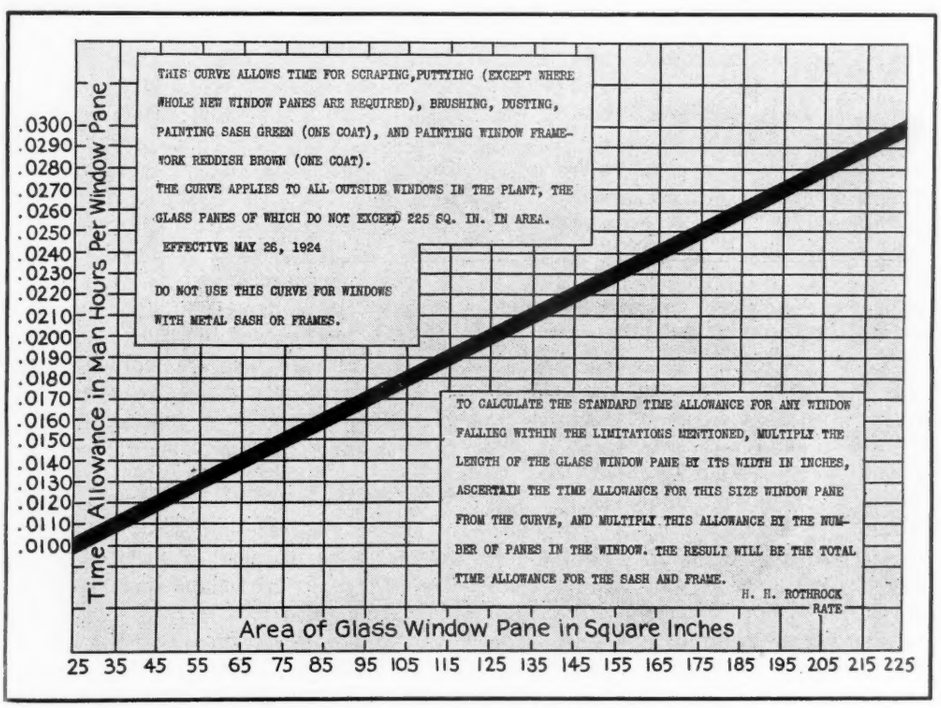
Mr. Lowry states that even though this survey is made primarily as a matter of record, the greatest benefit is probably to the time study engineer who is to supervise painting, because he is obliged to familiarize himself with the details of the department and its operation, in a logical and systematic manner. This conclusion is one that we might expect, because of the fact that time study, by its very nature, requires great attention to detail.

With the set-up made, the time study engineer finds the painting department measurement of tasks is the next step. Each operation of a given piece of work—let us say painting windows frames, a fairly simple operation—is subjected to close analysis. Every unnecessary operation is eliminated, and the quickest and best method of performing the necessary movements is established. Equipment, methods, and working conditions are standardized to determine by scientific measurement the standard time in which an average man can do the job.

The gist of this reasoning is that the standard is neither a minimum nor a maximum, but the one which can be attained by an average man when applying himself honestly to his work. Since the average man is an impossibility, the average performance of many painters of various skills sets the standard. I'll skip any effort to differentiate the various types of workmen. To these standards, when reached, are added allowances for fatigue, relaxation, and personal needs. They vary, but a fair set-up might be 10 per cent for light work with considerable stand-by time, to 25 per cent and 30 per cent for heavy hand labor.

Each element of the operation is considered separately. The standard for the operation is the aggregate of all elements.

Thus systematic charts are made to cover all of the painting operations which are routine. The accompanying charts and tables show some


THIS CURVE ALLOWS TIME FOR SCRAPING,PUTTYING (EXCEPT WHERE WHOLE NEW WINDOW PANES ARE REQUIRED), BRUSHING, DUSTING, PAINTING SASH GREEN (ONE COAT), AND PAINTING WINDOW FRAMEWORK REDDISH BROWN (ONE COAT).
THE CURVE APPLIES TO ALL OUTSIDE WINDOWS IN THE PLANT, THE GLASS PANES OF WHICH DO NOT EXCEED 225 SQ. IN. IN AREA.
EFFECTIVE MAY 26, 1924
DO NOT USE THIS CURVE FOR WINDOWS WITH METAL SASH OR FRAMES.
TO CALCULATE THE STANDARD TIME ALLOWANCE FOR ANY WINDOW FALLING WITHIN THE LIMITATIONS MENTIONED, MULTIPLY THE LENGTH OF THE GLASS WINDOW PANE BY ITS WIDTH IN INCHES, ASCERTAIN THE TIME ALLOWANCE FOR THIS SIZE WINDOW PANE FROM THE CURVE, AND MULTIPLY THIS ALLOWANCE BY THE NUMBER OF PANES IN THE WINDOW. THE RESULT WILL BE THE TOTAL TIME ALLOWANCE FOR THE SASH AND FRAME.
H. H. ROTHROCK
RATE
Time Allowance in Man Hours Per Window Pane
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.0140
.0130
.0120
.0110
.0100
Area of Glass Window Pane in Square Inches
25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225

Fig. 1—Time allowance for window painting.

of the standards at the Westinghouse East Pittsburgh works. Fig. 1 is the curve for painting window frames. Fig. 2 shows the time data for painting pipes, Fig. 3 the time for regular structural steel shapes, and Fig. 4 contains various standards for the interior of a building. The unit of measurement, that is the time allowed, in all these charts, is expressed in decimal parts of an hour.

One point always must be kept in mind. Success is due to thoroughness. Not only on the job itself, but in all phases of preparation for the job, the painter is paid on an incentive basis. Fig. 5 shows how the Procter and Gamble Company has charted the plant with the paint department as a hub and knows exactly how long it takes to walk from one spot to another. Some of the units look humorous at first sight (witness man walking up or down one flight of steps and man walking up and down one flight of steps with load), but that attention to detail is the prime element in wage incentive success.

There are certain operations where the group, instead of the man, becomes the basic measuring stick. Two painters on a sliding scaffold painting an exterior would be such a case. The incentive procedure is the same. You may also wonder how a painter is going to familiarize himself with all of these ramifications. He isn't. He simply fills his time card by telling where he worked—the time study engineer does all the rest. If this seems like an addition of a tremendous amount of clerical labor, the comparative results that I shall give will surprise you.

Inside Diameter of Pipe	Outside Diameter of Pipe	Periphery of pipe in Inches	No. of Sq.inches per foot of Pipe	No. of Sq. feet per foot of Pipe	Value per lineal ft. 1st Coat	Value per lineal ft. 2nd coat
3/4"	1.05	3.30	39.6	.28	.0025	.0023
1"	1.32	4.17	50.0	.35	.0032	.0029
1 1/4"	1.66	5.22	63.0	.44	.0040	.0036
1 1/2"	1.90	5.97	72.0	.50	.0045	.0041
2"	2.375	7.46	89.5	.62	.0056	.0050
2 1/2"	2.875	9.00	108.0	.75	.0068	.0061
3"	3.50	11.00	132.0	.92	.0083	.0075
3 1/2"	4.00	12.57	151.0	1.05	.0095	.0085
4"	4.50	14.14	169.7	1.18	.0106	.0096
4 1/2"	5.00	15.71	188.5	1.31	.0118	.0106
5"	5.56	17.47	209.6	1.45	.0131	.0117
6"	6.625	20.81	249.7	1.73	.0156	.0140
7"	7.625	23.95	287.4	2.00	.0180	.0162
8"	8.625	27.10	325.2	2.26	.0203	.0183
9"	9.625	30.24	362.9	2.52	.0227	.0204
10"	10.75	33.77	405.2	2.82	.0254	.0228
11"	11.75	36.91	442.9	3.07	.0276	.0249
12"	12.75	40.00	480.0	3.33	.0300	.0270
	13.00	40.84	491.0	3.41	.0307	.0276
	14.00	43.98	527.8	3.66	.0329	.0296
	15.00	47.12	565.4	3.93	.0354	.0318
	16.00	50.27	603.2	4.19	.0377	.0339
	17.00	53.41	640.9	4.45	.0400	.0360
	18.00	56.55	678.6	4.71	.0424	.0382
	19.00	59.69	716.3	4.97	.0447	.0403
	20.00	62.83	754.0	5.24	.0472	.0424
	21.00	65.97	791.6	5.50	.0495	.0446
	22.00	69.12	829.4	5.76	.0518	.0467
	23.00	72.26	867.1	6.02	.0542	.0488
	24.00	75.40	904.8	6.28	.0565	.0509
	25.00	78.54	942.5	6.55	.0590	.0531
	26.00	81.68	980.2	6.81	.0613	.0552
	27.00	84.82	1017.8	7.07	.0636	.0573
	28.00	87.96	1055.5	7.33	.0660	.0594
	29.00	91.11	1093.3	7.59	.0683	.0615
	30.00	94.25	1131.0	7.85	.0707	.0636

Fig. 2—Standard time data for painting pipes.

Compensation

If the painter is unable to do his work in the standard time, he still receives his regular hourly rate. He cannot lose, except by being so inefficient that he must be discharged. If he does better than standard, he receives his hourly rate plus the premium for his extra energy. In practically all cases standards are so intelligently set that monthly premiums run from 10 to 25 per cent. To me this is the real cause of the success of wage incentives. The painter realizes that he cannot get any less than his hourly base, and after a few months invariably finds he can get much more.. The problem of labor is solved, and wage incentives enthusiastically accepted. Mr. Lowry feels that painters who apply themselves industriously to their jobs may equal or exceed 20 per cent premium under Procter and Gamble standards. However, this requires intelligent planning and scheduling of work by the foreman.

An estimate of a Westinghouse painting job is shown by Fig. 6. Painting the interior of Section M.C., between columns 1 to 17, is the task. The total time necessary, as estimated by the time study department is 1,128 working hours. This is increased to 1,140 to include any differential in time that may be overlooked. The job took 1,021 hours, a record of 111.7 per cent, considering 1,140 hours as 100 per cent. For the workmen on this job, a group job, the premium was 11.7 per cent.

It seems fair and logical that the increased output is partly due to better planning and scheduling of work by supervision and management. So at Procter and Gamble the premium is divided, four-fifths to labor and one-fifth to supervision. This one-fifth is pooled for the premium for foremen and supervisory detail workers.

Control

In presenting a brief description of wage incentives to the foremen at Procter and Gamble Mr. Lowry had this to say regarding control, the last step in the wage incentive set-up:

"Control is that part of the plan designed to place before the plant executives a weekly summary of the exact labor situation in each department. This, to my mind, is the most valuable feature of the whole plan. We are attempting, in a scientific manner, to make both a qualitative and quantitative analysis of those variable and somewhat intangible factors which, when in proper relation to each other, make for low labor costs, and when not in proper relation, make for high costs. If for no other reason than to see once a week a cross sectional analysis of the true labor situation in each department, it seems to me that wage incentive would justify itself.

"To get the most out of our plan, the foreman must be more 'on his toes' than ever before. He must plan ahead more accurately and anticipate his labor requirements far enough ahead to make satisfactory disposition of surplus labor and to arrange to secure additional labor when needed. The extent to which he does those things will determine the amount of premium he will earn personally, and greatly influence the earnings of his men."

Painting Incentive Results

So much for ways and means; here are the facts and figures: The common method of measuring cost reduction is to compare used current unit costs and work unit costs for a representative period before incentives were applied. After somewhat over two years of application in the Ivorydale plant of the Procter & Gamble plant there has been a reduction of 29 per cent in the labor costs and the plant is better painted than ever before.

Neither the painting payroll (between 10 and 15 men) nor the actual dollars of painting budget has been greatly reduced, but the amount of work done by the painting department has increased by nearly 75 per cent, due partly to more frequent painting and partly to new work and the taking over of work formerly done by the production departments.

The number of hours is the same and working conditions are, if anything, better than before incentive was established. There is, also, considerable improvement in the planning and scheduling of painting work. While savings are important, what is of equal or greater interest to the Procter and Gamble management is that the painters have been able to earn approximately 18 per cent premium over their base wage. This attitude is consistent with the company's numerous well-known policies and plans to permit the employee who so desires to better himself. Fig. 7 gives a composite of results in the painting, car repair, truck repair, and tank building departments. The last-named is considered a maintenance department.

At Westinghouse were other interesting results. On spray painting, a group consisted of two tanks, four guns and 13 men before incentive. Now this equipment is handled better by six or seven men. Charts are charts, but opinions are more valuable because they record enthusiasm or lack of it. I asked a half-dozen superintendents at Westinghouse what they thought had been the percentage of increase in production due to wage incentive. Enthusiastic opinions ranged from 25 to 75 per cent. Though comparative figures were lacking the feeling of plant engineers, building superintendents, and paint time study supervisors was that about 40 per cent more work was done with a greatly decreased staff of painters. Every workman was receiving more money than under the old hourly rate system. Westinghouse has even put janitresses on incentive. That seems like a stiff task, but it reduced the number from 35 to 12 in a new office and the building is just as clean. Rush work, which might seem a drawback, particularly in painting and cleaning, is seldom met. The simplicity of application does away with this feature.

One statement in closing the topic of incentives. A comparison of all departments on incentive at Ivorydale shows that larger savings have been accomplished in painting and other maintenance departments than in production divisions. The field is virginal and offers immense possibilities. It must be remembered that large savings will be difficult to realize without enthusiastic support by supervision because it is necessary to apply pressure to break down precedents that for a long time have been associated with certain crafts. A case in point is the more or less acceptable tradition that every craftsman must have a helper. This has been abolished in some instances. On the other hand, present conditions demand a more careful consideration of our extensive efforts to secure more work with fewer men.

The Simonds Saw Plant

Doubtless you have read much about the new plant of the Simonds Saw & Steel Company. Above all else Mr. Simonds stressed the point that the new plant at Fitchburg is not radical. It started as an ordinary plant and finished as the plant that it is because of the conglomeration of common sense ideas. A hypothetical factory was raised, demolished, and reconstructed along lines following no fundamental engineering ideas, but answering primary, common sense questions. When the building is completely erected within three or four months it will still be subject to any kind of change. In other words, Mr. Simonds feels that all of the study which has gone into the making of the building will be valueless if that study is considered ended with building erected and machinery in operation.

First consideration was given to securing the most economical plant and layout. The original model set up was three stories and basement with gravity production. Final decision was for a single-story building with straight-line production. The first building would have used 13 acres of floor space at $2.64 per sq.ft. The final result will cost $3 per sq.ft., but there will be only four acres of floor space. The tempering and hardening departments, due to dirt, fumes and noise, were to be in separate, small buildings. They are included in the one large room that constitutes the entire plant. Not without difficulty, however; this arrangement meant a complex complete ventilating system. It meant sound proofing. The result was a windowless factory (concession to sound) and a complete change of air every 8 minutes (concession to living conditions). All of which

Dimensions of Angles Single	Dimensions of Angles Double	Dimensions of Channels	Dimensions of I-Beams	Periphery in Inches	No. of Sq.inches per foot	No. of Sq. feet Per foot	Value per lineal ft. 1st coat	Value per lineal ft. 2nd Coat
2" x 2"				8	96	.67	.0067	.0062
2½"x 2½"				10	120	.83	.0083	.0075
3" x 3"				12	144	1.00	.0100	.0090
3½"x 3½"				14	168	1.17	.0117	.0105
4" x 4"				16	192	1.33	.0133	.0112
5" x 5"				20	240	1.67	.0167	.0150
6" x 6"				24	288	2.00	.0200	.0180
	2" x 2"			12	144	1.00	.0100	.0090
	2½"x 2½"			15	180	1.25	.0125	.0113
	3" x 3"			18	216	1.50	.0150	.0135
	3½"x 3½"			21	252	1.75	.0175	.0158
	4" x 4"			24	288	2.00	.0200	.0180
	5" x 5"			30	360	2.50	.0250	.0225
	6" x 6"			36	432	3.00	.0300	.0270
		3"		11.8	139	.96	.0096	.0086
		4"		14.4	173	1.20	.0120	.0108
		5"		16.7	200	1.39	.0139	.0125
		6"		19.2	230	1.60	.0160	.0144
		7"		21.6	259	1.80	.0180	.0162
		8"		24.4	293	2.03	.0203	.0183
		9"		27.3	328	2.27	.0227	.0204
		10"		30.1	361	2.51	.0251	.0226
		12"		34.9	419	2.91	.0291	.0262
		13"		41.3	490	3.40	.0340	.0306
		15"		42.8	514	3.57	.0357	.0321
			3"	15	180	1.25	.0125	.0113
			4"	18	216	1.50	.0150	.0135
			5"	22	264	1.83	.0183	.0165
			6"	26	312	2.17	.0217	.0195
			7"	30	360	2.50	.0250	.0225
			8"	33	396	2.75	.0275	.0248
			9"	36	432	3.00	.0300	.0270
			10"	39	468	3.25	.0325	.0293
			12"	45	540	3.75	.0375	.0338
			15"	54	648	4.50	.0450	.0405
			20"	68	816	5.67	.0567	.0510
			24"	76	912	6.33	.0633	.0570

Fig. 3—Standard time data for painting structural steel.

skips the outstanding experiments in human engineering (no desks, galleries for foremen, elimination of written orders and reversion to the old school room verbal system, central radio, etc.), and brings us to this huge, single-story, four-walled, windowless, sound-proof structure, awaiting the finishing touch—a final colorful coat of paint.

Prior to selecting a paint color, Mr. Simonds had made a series of novel changes in a letter preparation firm in New York, endeavoring to change the working conditions for the girls employed to a beneficial maximum for their own enjoyment and health. Lighting and painting changes were most necessary. With the lighting at a good constant, Mr. Simonds made changes in the painting of various departments and showed that the congenial colors and the colors with a high light-reflecting efficiency could increase the output of these girls, as measured by their earnings, from $35 to $45 a week.

What is lighting? What is the best lighting? Where does painting fit in? Mr. Simonds contends that he doesn't, and perhaps never will know. Perhaps, when we consider his experience and the results achieved, we might place the word "definitely" before the word "know." At present he has advanced to a light which is the closest parallel to daylight yet achieved. As a sample test the naked eye cannot distinguish a difference in the reception of two pictures, one day-lighted, and the other lighted by the new Neon tube.

But further, when is daylight best, the heart happiest, the task most joyous? Though you may disagree, Mr. Simonds feels that spring is the time of year incorporating a bit more of the joy of living than any other. What are the colors of spring? Blue sky and budding green seem to be the answer. They were for a while. But under test the blue and green didn't stand up as plant colors. Mr. Simonds tested, visited, sat in the fields on spring and summer and fall and winter mornings. He watched farmers plow and plant, watched workmen and their reactions to various colorful surroundings. Green gave an easy, blue a cool feeling, with just a bit too much ease and coolness to suit. White and red, where did they fit as color components? White—neutral and clean—ideal for the nursery or child's hospital; it gives the parents a feeling of ease because the child is in such sanitary surroundings. The adult hospital room should be cream, ivory or buff, retaining the feeling of sanitation and less enervating for the patient's nerves. What is exciting, what do you associate with a picture of a harem? The example is Mr. Simonds. The reaction I have is red. In a measure red is the component needed in the paint color set-up. At that time he showed me three color chips, cream for the ceiling, buff for the walls, orange for the machinery. It must be remembered that the percentage of light reflection was not a factor in choosing these paint colors; the lighting being so good, the best psychological colors are chosen. Of course they must remain in the light tint range, and have a reflection value of over 50 per cent.

For the machinery this disregard of light reflection doesn't hold true. An orange has good reflection value and also the brightness and lift so requisite in a windowless plant. Tests showed Mr. Simonds that even though the workman does not feel that the lighter color of the machine helps, change him from an orange to a black machine, on the same task, and he will not do as well. If he tries to speed up, his workmanship deteriorates. If his quality is the same, his work is slower.

The Wright plant, where "Arch-Preserver" shoes are manufactured, is an old plant. The buildings are well kept but of the old style with low ceilings, timbered beams, and wood construction. It is the exact opposite of the new ideas and new plans incorporated in the Simonds Saw plant.

Mr. Donovan, president of E. T. Wright & Company, is a firm believer in the use of whatever means are available to increase the cheeriness of the employees' working conditions and general business.

A short time ago he decided that the entire plant needed general overhauling, and more particularly a general repainting, in order to give it the cleanest apparearance possible, and to brighten up the interiors. Walls, ceilings, partitions were painted white. On account of the low ceilings this greatly increased the lightness of interior spots, even though the plant is laid out to efficiently use all the light that enters through the unusually large number of windows.

But the striking thing developed by Mr. Donovan is the machinery painting. He believed light colors would improve the appearance of the machines and the operators' efficiency and would relieve a considerable amount of strain on eyesight. He proposed that the operators should choose for themselves the colors they wished to use to replace the black previously used on all machines. When he propounded his scheme to his works manager, superintendents, and foremen, it did not meet with a great deal of enthusiasm. These men felt that it might be a bit beneficial but not enough to warrant the cost and the time. Not only the officials but some of the workmen were antagonistic, their reaction being prejudiced toward colors which they felt were, if anything, effeminate.

However, one group was given its choice and experimented on its own machines. All painting was done with brush by the operators during the slack periods in 1930. There was absolutely no effort made to do anything but a very thorough job of painting.

"It seems to me that your difficulty is caused by an improper background," Mr. Donovan said to one em-

Operation		Dec. Hrs.	Reference
Paint side walls from ground	1st coat-brush(PerSq.Ft.)	.0080	W.U.- 3-16-25
" " " " scaffold	2nd coat- " (")	.0072	" - 3- 8-26
" " " " "	1st coat- " (")	.0090	" - 3-16-25
" ceiling " "	2nd coat- " (")	.0081	" - 2-24-26
" " " "	1st coat- " (")	.0090	" - 3-16-25
Spray walls	2nd coat- " (")	.0081	" - 2-24-26
" above wall line	(")	.0045	" - 10-5-26
Paint dado line on walls	(")	.0060	" - 9-29-26
Paint commode compartment	-brush(Per Ft.)	.0150	" - 9-29-26
" "	1st coat- "	.5600	" - 3- 6-26
Paint washstand in lavatory	2nd coat- "	.5000	" - 3- 8-26
" " "	1st coat- "	.0600	" - 2-18-26
Paint corrugated sheet iron	2nd coat- "	.0540	" - 3- 6-26
Paint structural steel -angles, etc. -	- " (PerSq.Ft.)	.0100	" - 6-15-27
Paint wooden window sashes, area of pane up to 225 Sq.in.	" (")	.0100	" - 6-15-27
" " " " " "	over 225 sq.in.		
" metal window sashes	(Sq.In.)	.00012	" -10-11-26
Paint wooden framework of window (3'6" x 8'0")	(Sq.In.)	.00012	" -10- 5-26
Paint window in N.W. Bldg. (20 panes 9" x 13")		.3000	" - 8- 9-24
	(Per Window)	.8400	" -10-15-24
Shellac or varnish - 5" strip	(Per Ft.	.0055	" - 3-16-25
" " " - 6" baseboard	(")	.0060	" - 3-16-25
" " " - 9" strip or panel	(")	.0100	" - 3-16-25
" " " - molding	(")	.0040	" - 3-16-25
" " " 1 window (Pane 29" x 25")		.1500	" - 3-16-25
" " " 1 window (2 panes 34 " x 32")			
	No shield	.2500	" - 3-16-25
" " " 1 window (2 panes 34" x 32")			
	With shield	.3000	" - 3-16-25
" " " Door (32" x 58")		.1500	" - 3-16-25
" " " Door		.2000	" - 3-16-25
" " " Table (20' 0" x 3' 0")		.5000	" - 3-19-25

Fig. 4—Standard time data for painting the interior of a building.

WAGE INCENTIVE STANDARDS

PAINT DEPARTMENT

IVORYDALE

Revised Standards as of March 1, 1930

	Units	
Assemble equipment at shop per job		
Spray painting - per man	1.5	
Brush painting - per man	1.0	
Walking time - Refer to walking chart		
Load of 10 to 25 lbs. = 1.5 walking time		
" " 25 to 50 lbs. = 2. walking time		
Walking up or down 1 - flight of steps	.2	
" " " 1 - " " " with load	.4	
Obtain paint (interval between enter and leave shop)	1.0	
" any materials other than paint	.5	
Transport ladders, scaffolds and rigging		
1 - trip per step ladder	1.5	Walking Time
2 - trips " 18' straight ladder		
2 - " " 18' scaffold board		
3 - " for ropes, blocks and hoops		
Transport Canvas to cover floor	1.5	Walking Time
1 - trip for 24' x 24' canvas		
1 - " " 4 - small canvas		
Erect scaffolds (Time allowed for getting on and off)		
Set up step ladder	.4	
Set up 2 - step ladders and put board		
5 to 8 ft. above floor	2.5	
8 to 15 ft. " "	3.0	
Set up extension ladder	1.4	
Set up 1 - 18 ft. straight ladder	.4	
Set up 2 18 ft. straight ladders and put board		
5 to 8 ft. above floor	3.7	
8 to 15 ft. above floor	4.5	
Set up adjustable trestle scaffold and board	6.0	
Move board 5 ft. along trestle	.3	
Erect 1 - Swing scaffold		
Hang hooks to eaves	5.0	
Hang from lookout, including putting up and taking down	10.9	
Moving scaffold and ladders		
Move scaffold from one beam to another with ropes. Per move	2.15	
Step ladder moves	.3	
1. Allow 15 moves per 100 lineal feet of wall		
2. Allow 1 move per sq. ft. of ceiling		
2 - Step ladders and board	1.0	
Board 5' to 8' above floor	1.5	
1. Allow 6 moves per 100 lineal feet		
2. Allow 1 move per 140 sq. ft. of ceiling		
Extension ladder - move	.6	
Straight ladder - move	.4	
1. Allow 15 moves per 100 lineal feet		
2 - Straight ladders and board 16 ft. long		
Board 5' to 8' above floor	3.7	
Board 8' to 15' above floor	4.5	
1. Allow 6 moves per 100 lineal feet		
2. Allow 1 move per 140 sq. ft. of ceiling		
Adjustable trestle and board	1.5	
1. Allow 1 move per 360 sq. ft. of ceiling		
Move board 5 ft. along trestle	.3	
Swing scaffold		
Sliding hooks along support	2.5	
Take hooks down and put up again	5.0	
Hung from look out	3.3	
1. Allow 5 moves per 100 ft. for 20 ft. swing scaffold		
A. Raise scaffold, fasten ropes, and get on scaffold. Per foot raised	.076	
B. Lower scaffold - 5 feet	.277	
Move stage around pipes and rafters in Glyc. and Lye Treat Hse.	3.3	
Spread canvas on floor (drop cloths)		
100 to 360 sq. ft.	1.5	
Tie canvas above machines - 4 corners	5.0	
Small drop cloths (up to 100 sq. ft.)	.3	
Moving spray machinery and equipment		
Prepare compressor to move	2.7	
Prepare block and tackle	.5	
Prepare gun pot and hose for moving	5.7	
Move compressor 2 x Walking Time		
Move 1 pot and hose 1 - trip		
Begin day's work after equipment is on job		
Prepare compressor for use	2.7	
Connect and disconnect air hose	3.6	
Prepare gun and pot	.9	
Clean gun and pot	5.0	
Fill spray pot	.5	
Marking off with chalk line (Dado)		
Per 100 lineal feet if layed off 25' or more at a time	3.	
Per 100 lineal feet if layed off less than 25' at a time	5.	
Paint Dado		
Extra value for painting along where colors meet per lineal foot	.07	

Fig. 5—Wage incentive standards, paint department, Ivorydale plant of the Procter & Gamble Company.

ployee. "The body of your machine is black and so are its working parts. There is no contrast and it is a great deal like trying to thread a needle in the dark. Suppose you paint the body a light blue and see what the effect will be."

The workman, who operates a heel-edge scouring machine, carried out the suggestion and reported the result to be amazing. "Now I can do more and better work," he said. "The background has made it possible for me to see better, and therefore I enjoy my work more. My eyes are not as tired at night as they used to be and I am in better humor throughout the day."

After a few sections were repainted everyone became enthusiastic and all types of machines were given the bright colors now prevalent throughout the shop. These colors are not only on the light side of the base color, but the very light, effeminate colorings—orchid, rose, pale greens, soft blues, Chinese pink, and others predominate.

In the lining and fitting department the machinery is done in a green. Some of the operators have even gone so far as to paint the handles of their hammers green, benches are green, motors on the tables are green, switch boxes ivory. An interesting feature of this department, which has a western exposure, is the use of buff curtains to diffuse the sunlight during the afternoon hours. White was found to be a bit too strong, while buff was preferred to green which seemed to absorb a great deal of the light. Elevators are in red—that is, the entire machine, top, bottom, side walls inside and outside are the same danger red as the fire lines throughout the plant.

The lasting department is in a small room and the lasting machinery is placed in rows near the walls and windows. The row next the wall is done in orange and the row next to the window in orchid. The foreman's desk is in orchid and the entire room gives a distinct feeling of vigor to the person who enters it. Walls are white, fire lines red, and other pipe lines a bright orchid and orange.

In the department containing the heeling machines the workmen chose orange as the color they wished to use. They liked it so well that they painted not only the machines but the outside of the belting. Then they purchased, at their own initiative and expense, orange jackets to wear while working.

Many of the machines are painted in two and three colors. There is a predominant light color and a trim color of some complementary or contrasting note. Particularly dangerous machinery often is painted red at the most dangerous spots. Also many of the machines, which stand in darker portions of the plant, are painted in whatever color the workmen choose, and then in a very light buff or green at the spot where he must direct his attention while watching his work.

As we wandered through, Mr. Kain, the plant manager, said to one old sole fastener, "Well, Frank, how would you like to go back to the black machines?" Frank replied about as follows: "Mr. Kain, I have been working here for over 25 years, and my father was a shoemaker in this same neighborhood, but if I had to go back to the black machines we had a year ago I would pick up my kit and walk out tomorrow. I did not realize what was causing me to begin to feel my age—I am 63—until those machines were painted. My eyes were bothering me and I had to get glasses, and about three years ago I had to start wearing a broad belt to strengthen my back and help support my kidneys. When I got home nights I'd have a general nervous and excessively tired feeling and I was getting so I wasn't able to throw it off with a night's sleep. In fact I wasn't getting a good night's sleep more than once a week.

"When we decided on these light colors I noticed at once that my eyes were not bothering me as much as they were. Of course, I am too old to throw away my glasses

STANDARD TIME — Routing No.

Dwg. Title	Sec. L-13	Style Pattern		Dwg. No.	Sub.
Part Sec. M.C. Lot 1 to 17		Ins. Spec.		Item	
Mtl. Size Pcs. per 100 lbs.		Old Mold		L. Space	Sub.
Mach. Tool and No.		Spec Tool & Fixture		STANDARD TIME Set-up	STANDARD TIME Each Piece
Operation Spray & hand paint		Oprn. No. / Class of Labor	How Set		1140.00

Spray and paint end wall	45.00
" " " Bay # 1	47.00
# 2-3-11-12	200.00
# 4-5-6-7-8-9-10-13-14-15-16	561.00
# 17	90.00
	943.00
Get material to job and set up scaffold	110.00
Group Leader	30.00
	1083.00
Spray and paint 18 Columns from 1st to 2nd Floor	30.00
" " " Storeroom partitions & other partitions	15.00
	1128.00
Time taken 1020.88 hours	
111 .7%	

6/14/30

Recorded-Time Clerk | Cost Clerk | Date | Signed | Time Study Dept.

Fig. 6—Estimate of a Westinghouse painting job.

or do anything like that, but I do feel much better and I don't have nearly as much trouble getting to sleep at night. About six months ago I felt good enough to leave off the belt I had been wearing, and tried working for a few days without it. I haven't worn it since. My doctor tells me improvements in my health have been due to the relief from that constant strain I had been under for several years watching the stitching against the black background. And I am not the only one. Most of the old fellows around know that it has helped. Even the younger fellows who don't stop to consider their eyes feel that things are a lot better."

Another striking example was furnished by Mr. Kain when we wandered into the power plant: "You know how hard shelled most power engineers are. Even after we got this plan going, our power engineer bucked and said it was no good. Finally everyone was so enthusiastic he had to admit he was wrong and I want to show you what he is doing down here in the boiler room." He opened the door and I stepped into a place that looked as though it were being prepared for a continual Christmas carnival. The upper parts of the wall were white, the dado a startling green, and between the green and white a 4-in. stripe of red. This red, white and green Christmas color scheme was also followed out on the boiler itself.

Particular emphasis is laid on the painting of the basement for the simple reason that basements are usually dirty, unkempt, and eye-sores to everybody. The machines are in orchid and green, valves in green, and stud-bolts on the floor and many of the machines in orchid. The stamping machines and molding machines follow this color scheme and are particularly well done. Even the rubbish cans are colored to blend in with the general scheme.

The first machines to be painted thus were the grinders. A comparison was made on the machines which were still black and the new ones in their finished colorings. The advantages were so evident that they proved Mr. Donovan's theory and he immediately set forth to do the job throughout the entire plant. Only the blackening machines are still black and the browning machines a deep brown, due wholly to the nature of the work and the colors used, which would make excessively dirty the light colored machines.

Mr. Donovan names these outstanding benefits:

1. Elimination of eye strain. Color contrasts the products against the machine, resulting in finer and more uniform work without unduly taxing the eyesight.
2. Elimination of fatigue and nervous tension.
3. Reduction of accident rate.
4. Improved morale. Better attitude toward work. Better personal appearance.
5. Increased production.

Two other human sidelights are interesting. A few days ago, in a long distance conversation with Mr. Donovan, he read me a letter from the employees of one department, reprimanding him for not bringing a group of visitors through that department. It was as colorful, clean, and showy as any other, in their estimation.

And the day before Mr. Simonds had been in to look things over with Mr. Donovan. He's still subjecting those paint colors of his to scrutiny. Both of these men find paints and paint color as important a production means as are raw materials, machinery, and expert supervision.

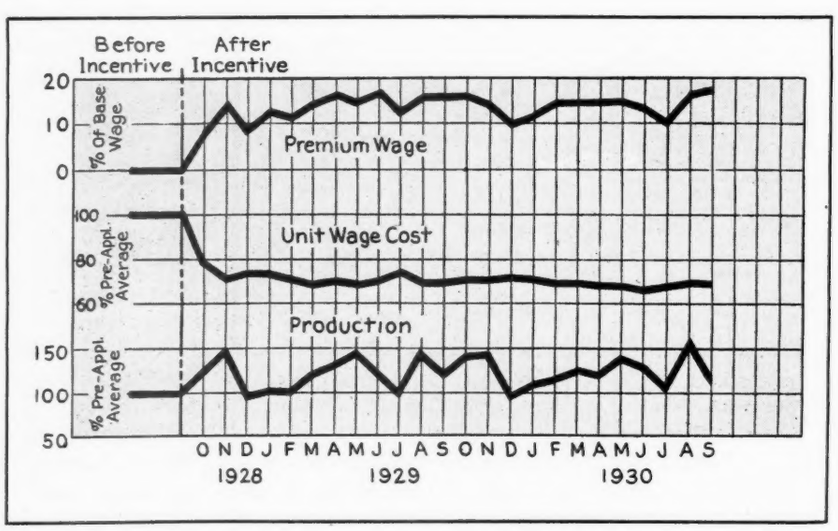

Fig. 7—Composite results of painting, car-repair, track-repair, and tank-building departments, Ivorydale plant of the Procter & Gamble Company. Note favorable trends of curves after installing incentive.

Maintenance of an Industrial Illumination System

Answers these questions, and others: What are the effects of dust upon intensity of illumination? How should bulbs and reflectors be cleaned? Should lamps be discarded before they have burned out? Should old and new lamps be burned together?

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IN THE average industrial plant the efficient operation of a well designed illumination system depends primarily upon two variable factors, lamp depreciation and dirt. If the exact rated voltage is applied to all lamps at all times, the decrease in efficiency through filament evaporation is easily determined from the manufacturer's laboratory tests. Also, a rough conclusion as to the approximate amount of dirt on a fixture may be reached at any time from a physical examination.

But, in the average industrial plant, voltage regulation is not economically feasible to a degree comparable to the regulation adhered to in laboratory tests. Furthermore, though the amount of dirt be actually determined for any one fixture or set of fixtures, no data were available to show the exact effect produced on the efficiency of the fixtures under our particular operating conditions.

In order to obtain definite data upon which to base recommendations governing systematic lamp renewals and cleaning schedules, at least within our plants, an efficiency and depreciation study of shop lighting fixtures in the Kearny Works was made over a period of eleven months from March, 1928, to January, 1929, inclusive. The immediate objects of the tests were to determine:

(a) The decrease in illumination intensity caused by varying amounts of dust, dirt, and fumes as found in different classes of manufacturing operations

(b) The effects of different cleaning methods

(c) The decrease in illumination intensity caused by natural ageing of the lamps

(d) The desirability of relamping fixtures after a specified time, even though the lamps would continue to burn.

In considering the results covered herein it is necessary to bear in mind the fact that no part of the study was in any sense a laboratory test. Therefore, irregularities may be noted which were caused by factors controllable in the laboratory but not easily controllable in the shop. No attempt was made at any time to adjust the voltage, since we felt that our voltage regulation was as good as the average within economical limits and since results were desired which would picture conditions as they actually existed, good or bad.

Illumination in all the locations referred to was furnished by glass-steel diffusers properly spaced and mounted to consume one watt per sq.ft. with 100-watt lamps, 2 watts per sq.ft. with 200-watt lamps, and so forth. The ceiling and upper walls were finished in clean, flat white and the lower walls (5 ft. 6 in. from the floor) in dark green. All readings were taken with a Macbeth illuminometer, the actual values recorded being the average of three readings at each position.

Four locations were chosen on various shop floors where conditions relative to dust, dirt, and fumes were representative of many similar locations throughout the plant. Two particular fixtures in each location were cleaned as thoroughly as possible with a dry cloth and equipped with new 200-watt lamps, together with red "hands off" tags. The second fixture in each location was kept under test merely as an alternate source of information in case the lamp in the first fixture burned out before the test was completed. The readings from only one lamp enter into the results. The four locations were as follows:

Location A—Relatively clean atmosphere, shop office
Location B—Light dust, small parts assembly
Location C—Heavy dust, cotton braiders
Location D—Fumes, insulating machines.

For 22 consecutive weeks, representing a total estimated burning time of approximately 1,000 hr., weekly illumination intensity readings were taken directly under each lamp.

At the end of the 22nd week all fixtures were again dry cleaned and the intensity noted. One fixture was then cleaned successively with carbon tetrachloride, soap and water, and a solution of trisodium-phosphate. The results obtained with the trisodium-phosphate were so far superior that the readings taken after the carbon tetrachloride and soap and water cleanings were discarded and trisodium-phosphate used exclusively as a wet cleaning agent on all of the remaining fixtures. A test was also made at the end of the 22nd week to determine the extent of lamp ageing.

A slight difference between the old and a new lamp

Location A—Clean atmosphere

could be noted on the iluminometer, but the difference was not sufficiently great to warrant the replacing of the lamp, or even to affect the performance curve to a noticeable extent. The old lamps were again installed.

Following the cleanings mentioned, the identical procedure was repeated for a second period of 22 weeks, at the end of which the test was concluded and all results plotted into curve form. Figs. 1 and 2 show the results.

Discussion of Lamp Depreciation Curves

The curves in Fig. 1 show the general trend of fixture efficiency, the results of cleaning, and the fact that the two halves of each curve, corresponding to the two halves of the test, are of decidedly different shapes, due, undoubtedly, to lamp ageing, which begins to show effect about the 28th week, and which accounts for the extremely low intensities recorded near the end of the tests.

It will be noted that for the first half of the test period each intensity curve begins to drop after a length of time depending upon the amount of atmospheric dust to which the fixture was exposed. For example, the fixture in the relatively clean atmosphere (location A) gives a fairly constant intensity for 16 weeks while the lamp exposed to fumes (location D) shows a decided decrease in intensity after the eighth week.

The effect of dry cleaning follows roughly the same rule, i.e., dry cleaning is relatively ineffective with heavy dust and fumes but fairly satisfactory with little or light dust. The wet cleaning method (trisodium-phosphate solution) accomplishes approximately the same results regardless of the character of dirt which has accumulated on the fixture, and in general represents a striking advantage over dry cleaning. This is especially evident from the fact that the intensity values after wet cleaning were far in excess of the original starting values.

Involved in the second half of the test is a new element which brings about a considerable difference in the shape of the curves. From the time of the first wet cleaning all curves drop very sharply. However, within the first few subsequent weeks each curve might well have been expected to straighten out approximately on the line of 10 foot-candles, as in the previous half of the test, had not the element of lamp depreciation entered into the results. That this element was definitely present is unquestionable after a consideration of the final readings. Thus, to curves already showing the effects of dust, was added the extra detrimental effect of lamp ageing, with the net result that the drop not only continued but was accelerated to a point appreciably below the figure reached at the conclusion of the first half of the test. At this low point neither wet nor dry cleaning resulted in any marked improvement. The installation of a new lamp brought all intensities approximately to the previous wet-cleaned value.

From these curves an immediate answer may be had to the two main questions,

(a) How often should fixtures be cleaned?

(b) Should old lamps be renewed before they actually burn out?

Concerning question (a), in our particular lighting system the average 200-watt lamp, reasonably new and reasonably clean, gives an intensity immediately beneath it of about 12 foot-candles. The intensity at the center of a square bounded by four regularly spaced 200-watt lamps is about 10 foot-candles, so that a good general average may be taken as approximately 11 foot-candles. This fig-

ure does not represent maximum possible efficiency, but we believe that it represents the highest efficiency which it is economically practicable to obtain, and an efficiency slightly higher than successful operation demands.

Let us assume, then, that the 11 foot-candles represent 100 per cent efficiency and that on such a basis we are willing to allow our system to operate at an efficiency of not less than 90 per cent. We now see that lamp D operated at an efficiency of 96 per cent for eight weeks after cleaning and dropped to 88 per cent at 12 weeks. Similarly, lamp C operated at 97 per cent efficiency for 9 weeks and dropped to 83 per cent in 14 weeks; lamp B operated at 93 per cent for 12 weeks and dropped to 88 per cent in 14 weeks; while lamp A operated at 93 per cent for 14 weeks and dropped to 89 per cent at 16 weeks.

From these figures we conclude that:

(a) Lamps exposed to heavy fumes, such as lamp D, should be cleaned every two months

(b) Lamps exposed to heavy dust, such as lamp C, should be cleaned every two months

(c) Lamps exposed to light dust, such as lamp B, should be cleaned every three months

(d) Lamps exposed to very little dust, such as lamp A, render satisfactory service if cleaned only once every four months, and that in none of these cases is there a marked advantage to be gained by cleaning oftener.

Based on these conclusions, definite cleaning schedules have been set up in accordance with actual manufacturing conditions for the whole Kearny plant. From our experience with cleaning methods we are able to say, also, that all cleanings should be of the wet type, using a solution of trisodium-phosphate or its equivalent.

Next comes the question of lamp renewals. The appreciable increase in intensity resulting from the installation of new lamps indicates a decided economic advantage to be gained by a systematic program for renewing lamps over the entire plant before they are actually burned out, especially since our average is somewhat low and lamp life consequently abnormal. Obviously, however, such a program would involve the keeping of expensive clerical records, the cost of which would undoubtedly offset the value of any resulting gain in illumination efficiency. Furthermore, such records would necessarily be highly hypothetical, since there exists no ready means of determining the exact number of hours that any particular lamp has burned.

In an effort to prevent the extremely low operating efficiency of very old lamps and at the same time to avoid the expense of keeping costly clerical records, a plan is being considered whereby all four lamps on any column or wall switch are to be renewed when any one burns out. By systematically following such a procedure a condition is eventually set up wherein all the lamps on any one switch in the plant are of exactly the same operating age at all times, and when one burns out the others may reasonably be presumed to have passed their period of acceptable efficiency. Naturally, some lamps burn out prematurely, and when such a case occurs, three other lamps automatically are thrown away even though they still retain a portion of their economic usefulness. Also, the expense for material is obviously greater than when one lamp is renewed at a time, though the expense for labor does not logically increase in the same proportion. The only hope of

Location B—Light dust

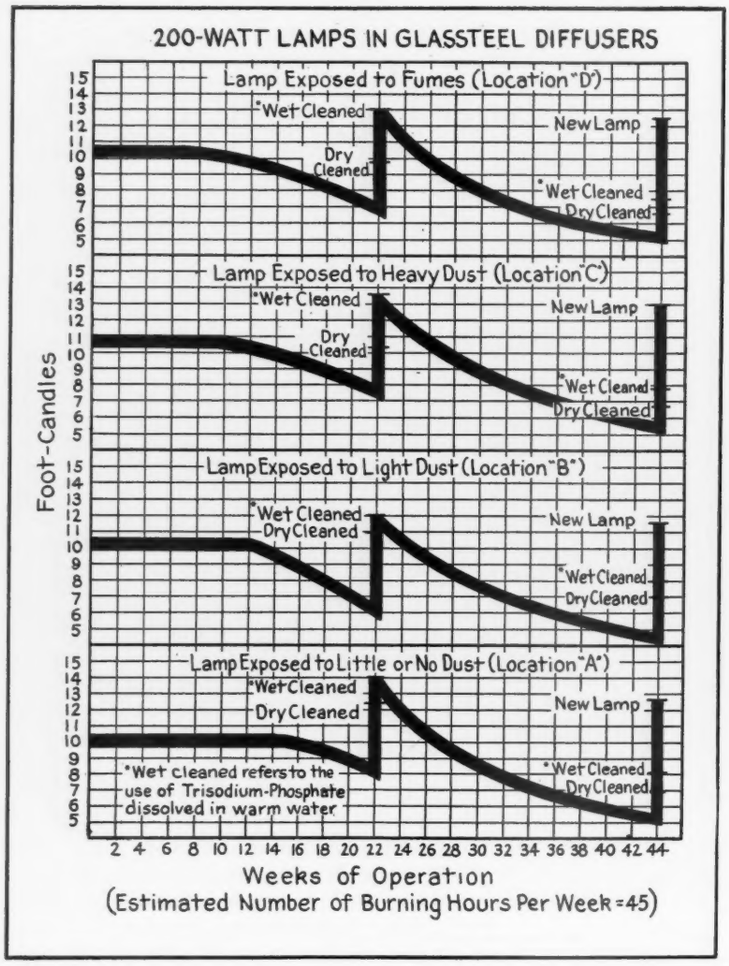
200-WATT LAMPS IN GLASSTEEL DIFFUSERS
Lamp Exposed to Fumes (Location "D")
*Wet Cleaned
Dry Cleaned
New Lamp
*Wet Cleaned
Dry Cleaned
Lamp Exposed to Heavy Dust (Location "C")
*Wet Cleaned
Dry Cleaned
New Lamp
*Wet Cleaned
Dry Cleaned
Lamp Exposed to Light Dust (Location "B")
*Wet Cleaned
Dry Cleaned
New Lamp
*Wet Cleaned
Dry Cleaned
Lamp Exposed to Little or No Dust (Location "A")
*Wet Cleaned
Dry Cleaned
New Lamp
*Wet Cleaned
Dry Cleaned
*Wet cleaned refers to the use of Trisodium-Phosphate dissolved in warm water
Foot-Candles
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44
Weeks of Operation
(Estimated Number of Burning Hours Per Week = 45)

Fig. 1—Lamp depreciation curves, showing depreciation due to dirt, the effect of cleaning, depreciation due to ageing of lamps, and the effect of lamp renewals.

offsetting these disadvantages lies in increased production or decreased rejection brought about through increased lighting efficiency.

The basic idea seemed sufficiently attractive to warrant further investigation. Accordingly, about April 1, 1930, a room similar to any of those shown in the cuts was divided longitudinally into two halves by an imaginary line down the center of the main aisle. Orders were issued that when a lamp burned out in one half of the room only that one lamp should be renewed, while in the other half, when any one lamp burned out, all four lamps on that particular switch were to be renewed at the same time. During the entire investigation accurate illumination efficiency and cost records, including both labor and material, were to be kept independently for each half of the room and compared at the end of definite periods.

At the present time the test has not been completed and therefore the data obtained have not been thoroughly analyzed. Over a period of about 10 months, however, the total cumulative expense for labor, material, and loading are about 4½ c. greater per fixture on the four-lamp side than on the one-lamp side of the room. The extra expense for lamps alone is about 7 c. per fixture, but an actual saving of 2½ c. per fixture in labor

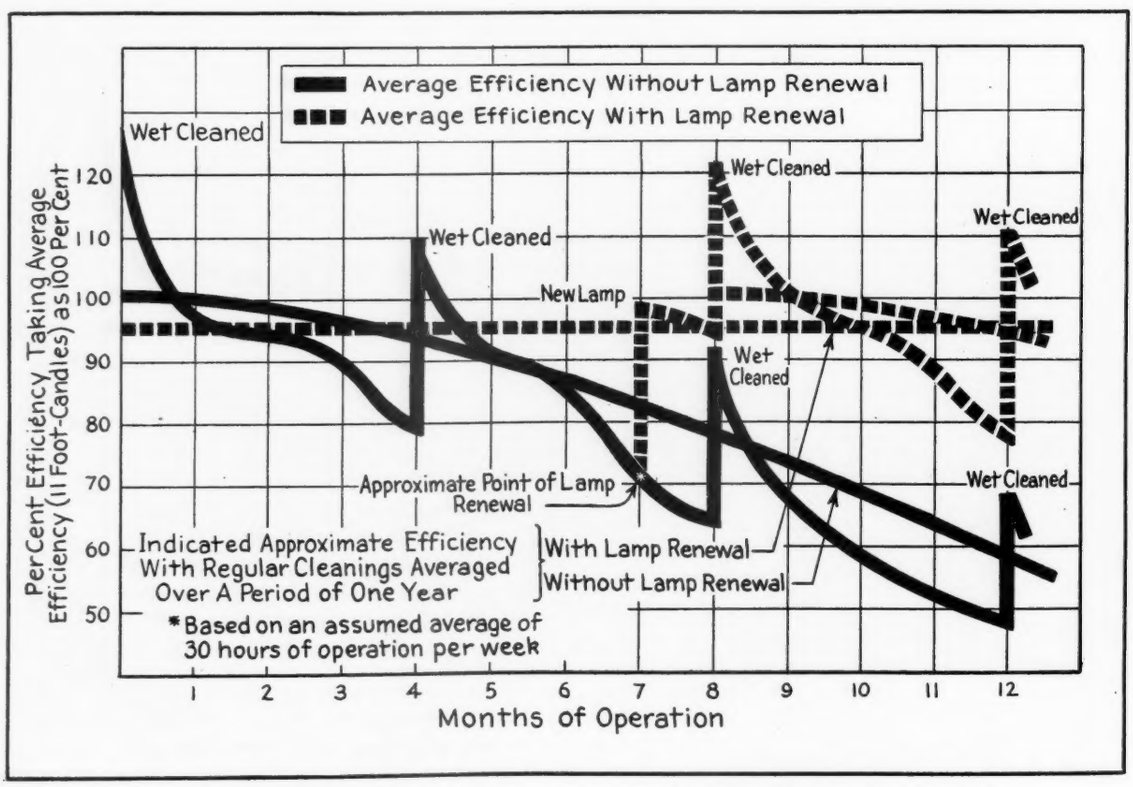

Fig. 2—Average lamp and fixture efficiency, showing advantage gained by lamp renewals.

Location C—Heavy dust

has been made on the four-lamp side. Contrary to the expectations, however, the illumination intensities on the two sides of the room have remained approximately equal. But less than half the total number of lamps on either side of the room have been renewed even after ten months of operation, and therefore an authentic indication of the ultimate gain in efficiency hardly can be expected.

While the eventual outcome of this test and the cost figures obtained are looked forward to with extreme interest, it is still felt that probably the most universally satisfactory method of preventing the extreme inefficiency of old lamps is to keep the circuit voltage as close as possible to the rated voltage of the lamp. The more closely the two voltages agree, the greater is the likelihood that the majority of the lamps will burn out at or near their rated thousand hours, and thus the extremely old lamps will automatically eliminate themselves. The chief reason for unusual interest in the results of the four-lamp renewal test lies in the previously mentioned fact that close voltage regulation in the average industrial shop is a far more difficult matter than the same degree of regulation in the laboratory where life tests usually are run.

Shown graphically in Fig. 2 is the extremely low efficiency resulting from the use of old lamps compared to the yearly average efficiency attained when systematic renewals are made. The efficiency values from which the curves are plotted are based on a composite of the four curves shown in Fig. 1.

Summary of Results

For the sake of ready comparisons the following percentage figures, covering the complete test, are tabulated. All the figures are based on the assumed 100 per cent efficiency corresponding to 11 foot-candle intensity.

	Location A	B	C	D
Average intensity taken as (foot-candles)....	11	11	11	11
FIRST HALF OF TEST (New lamp; fixture dry cleaned)				
Percentage of average intensity at start of test	93	93	97	96
Percentage of average intensity after 8 weeks	93	93	97	96
Percentage of average intensity after 12 weeks	93	93	93	88
Percentage of average intensity after 16 weeks	89	80	86	79
Percentage of average intensity after 22 weeks	73	56	69	63
Percentage of average intensity after dry cleaning at the end of 22 weeks.....	114	100	95	88
Percentage of average intensity after wet cleaning at the end of 22 weeks.....	127	112	125	121
SECOND HALF OF TEST (New lamp removed, old lamp put back, fixture wet cleaned)	Location 11	11	11	11
Percentage of average intensity after 26 weeks	98	87	100	93
Percentage of average intensity after 20 weeks	78	71	73	75
Percentage of average intensity after 34 weeks	66	60	68	64
Percentage of average intensity after 38 weeks	56	51	55	54
Percentage of average intensity after 44 weeks	48	45	50	48
Percentage of average intensity after dry cleaning at the end of 44 weeks.....	62	64	62	61
Percentage of average intensity after wet cleaning at the end of 44 weeks.....	73	73	71	68
Percentage of average intensity after wet cleaning and removal of lamps at the end of 44 weeks.....	116	107	116	116

An interesting fact brought out by these figures is that all fixtures, whether exposed to light or heavy dust, even-

tually will reach approximately the same state of inefficiency, and will, therefore, be equally benefited by cleaning.

At the conclusion of the test, an effort was made to determine the cause of the marked downward trend of the curves immediately after wet cleaning. A representative glassteel reflector was cleaned in small adjacent areas with a dry cloth and with trisodium-phosphate, and the two areas subjected to microscopic scrutiny. The dry-cleaned area showed many minute pores from which the dirt had not been removed, while the wet cleaned area presented practically the same surface as a new reflector. This fact leads to the theory that even when dry cleaning is thoroughly done, not all the dirt is removed from the pores of the reflector. These pores are efficiently cleaned by the wet method but rapidly fill up again when the reflector is placed in service.

Considering lamps in all four locations, it will be noted that during the first month after wet cleaning the highest intensity obtained was 127 per cent of the arbitrarily chosen 11 foot-candles, while the lowest was 86 per cent. The general overall average for the month was well over 100 per cent. Therefore the question may logically be asked: Why not wet-clean all fixtures every month, and thus obtain the benefit of extremely high efficiencies during the first week or so, and excellent averages during the entire month? The answer, in our opinion, is that the extremely high intensities are too short-lived to warrant the expense of such frequent cleanings. Any lighting intensity is valuable mainly insofar as it is reflected in production efficiencies. The high intensities entail from two to four times the cleaning expenses of our so-called normal intensities and these expenditures are not believed to be justified by production records.

Location D—Fumes

Departmental Analyses and Wage Incentives

How to analyze a department — Distinction between "work" and "results"—Application of wage incentive payment to the electrical maintenance task.

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DURING the past few years much interest has been shown in the subject of wage incentives. Meetings have been held and books and magazine articles written in an effort to advance the knowledge of this subject, but there is still one phase of it about which very little has been said. This phase deals with the relationship of departmental analyses and wage incentives.

I find that many executives are under the impression that the problem of wage incentives is a definite "yes" or "no" proposition; that they have to make a clean plunge into it by setting up several plans and putting them into effect almost overnight; or that they must have nothing at all to do with the problem. The contradicting stories of lowered costs obtained by some organizations which are successfully operating wage incentive plans, and of increased costs in other organizations which are experiencing rank failure with them, serve to disturb their peace of mind. These executives would like to take some definite action toward lowering their unit costs but they do not care to gamble with a method which has been a great help to some but a hindrance to others.

What, then, can be done in the way of taking some steps toward lower unit costs without installing wage incentive plans? And what can be done toward eliminating many of the possibilities of failure if wage incentive plans are desirable?

In attempting to answer these questions let us assume that the chief executive of a manufacturing organization is dissatisfied with the performance of some specific department paid on a time basis. It doesn't matter whether the organization manufactures large or small products, whether the work is of a production shop or jobbing shop nature, or whether the department in question is a shop or office, the same procedure can be followed in each case.

Measuring the Results

The executive's first step should be to order an analysis of the results of the department with which he is dissatisfied. This analysis should present the complete picture of the department and should be based on a unit which measures results, as well as items of work. It is not sufficient to measure work alone, unless that work is the final result for which the department is held accountable.

An example of this distinction between "work" and "results" can be found in the average salesman's job. The number of words in the letters he writes, the number of letters he mails, the size of the territory he covers, and the number of interviews he has, all are items of "work." But the volume of sales made and the ratio of sales to expense represent his "results."

If a practical measuring unit cannot be developed, the executive will have to continue to rely upon his general opinions rather than on a special report based on a detailed study of conditions, but in most cases a practical measuring unit can be developed, and after it has been applied to a department the findings should be set down in such a way that the performance in any one period can readily be compared with that of prior or succeeding periods.

This brings us to the second step which the executive should take, that of holding the department head accountable for good performance as it is indicated by the analysis. However, if the analysis is not sufficiently detailed to show what results may rightfully be expected, but shows only the results actually being obtained, the executive will

not know the true efficiency of the department although he will know whether the unit costs are higher or lower than those of preceding periods measured by the same unit.

An extreme case can be made up by assuming that an individual walks one block in one hour and at a later time that same individual walks the same block in 50 minutes. There is improvement in his performance but more than that we do not know unless we acquaint ourselves with the performance that can be expected of the average good walker. And when we know that a man can walk a block in less than two minutes, 50 minutes doesn't look nearly as good as it did when compared with 60 minutes.

It is needless to say that a thoroughly detailed analysis is more expensive than one which simply shows an actual unit cost without reference to a cost that may be expected if the department operates at top-notch efficiency. In view of this fact, it is advisable to let the specific departmental conditions indicate just how detailed this analysis should be. No one rule can be given to apply to all conditions.

The two steps of procedure which have just been outlined are given in answer to the question, "What can be done in the way of taking some steps toward lower unit costs without installing wage incentive plans?" They can be summarized by saying that the executive should have made an analysis of departments and when the findings have been set down in good form they should be used as a guide in his demands from department heads for lower costs or the maintaining of costs that are already low.

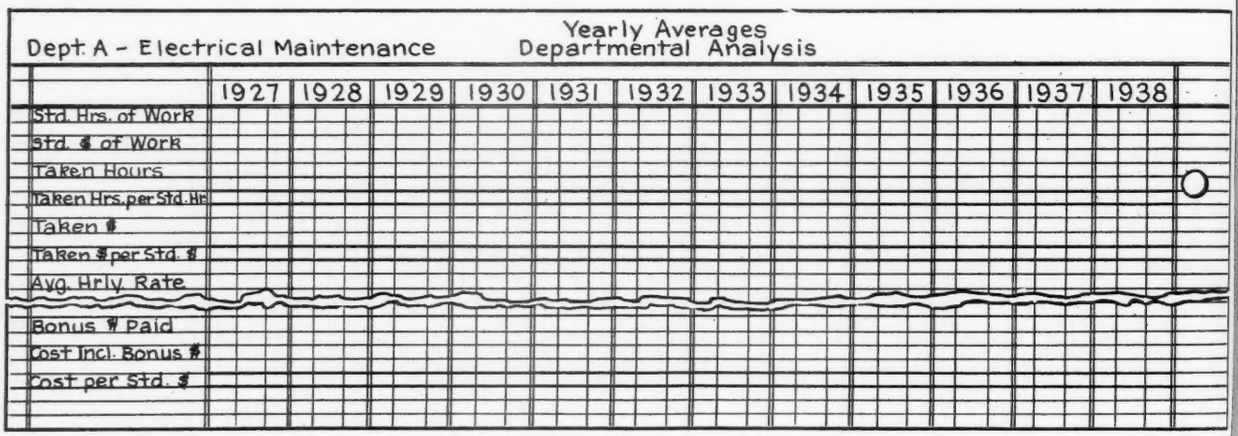
Departmental analyses should not be confused with the regular cost statements which provide for a distribution of all expenses and from which selling prices are determined. Such statements usually include some items over which the operators have no control and they do not include measuring units that embody all conditions. Departmental analyses, on the other hand, make a distinction between controllable and non-controllable items. They contain measuring units designed for definite conditions and often include special items for the sole purpose of obtaining a complete measurement of work and results.

Installing a Wage Incentive Plan

The second question, "What can be done toward eliminating many of the possibilities of failure if wage incentive plans are desirable?" presents the major problems of the first question. In view of this condition it is advisable to work up departmental analyses and to use them in holding the department heads accountable for results before wage incentive plans are made effective. This practice is recommended because a measuring unit should be carried on paper for a sufficient length of time to allow any weak points to come to light and to allow for the gathering of enough information for an intelligent determination of that reward which should be made for a given performance.

About six months should be allowed for the thorough testing of a plan during which period the analysis will guide the executive in controlling costs. To rush the installation of wage incentive plans is dangerous practice; for such plans are like dynamite, they can do much good when under control and much harm when they are not.

Now, let us assume that the executive has carried the proposed wage incentive plan on paper for six months and that it has stood the test of time satisfactorily. He has one more opportunity to check himself if he so desires. The plan can be made effective for the department head alone and at some later date the entire group may be allowed to participate. Of course this method may not be practicable or desirable for every department or every organization. Its value will depend upon definite conditions.



Form of ruled sheet for Department Analysis,

It is necessary to bear in mind that wage incentive plans which have been put into effect are similar to departmental analyses in that the executive must keep in almost daily touch with performance records and the employees must know that he is doing this or the maximum benefits will not be obtained. This statement does not belittle the value of wage incentive plans but points to a duty of management if management really is serious in its cost reduction work and if it wishes to show the operators that unit costs are worthy of much study.

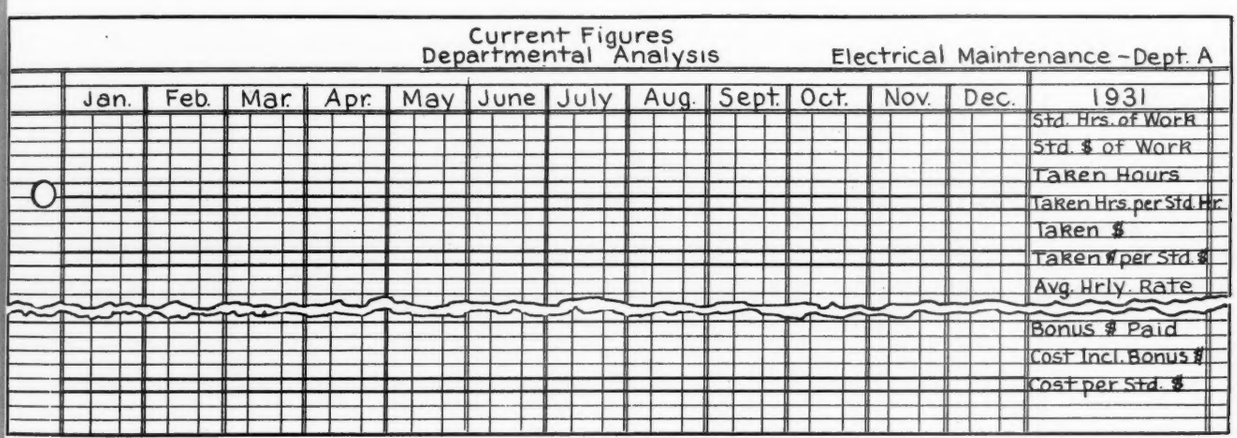
It is my hope that the thoughts which have been outlined will indicate that it is neither necessary to make a grand plunge into the problem nor keep out altogether. One can get into it by degrees and check himself as he goes along. And this thought of "checking as you go along" applies to the expense of making the analyses since it can be compared with the benefits obtained and the results of this comparison can be used to justify the continuation of work along this line.

Records of performance can be kept on 8½x11-in. forms which provide one wide column for the names of items and 12 or 13 columns for figures. Forty or more lines should be drawn across the columns.

These forms should be printed on both sides and should be bound on the edge farthest from the wide column, in a loose leaf binder. All monthly or period figures pertaining to the Departmental Analysis should appear on one sheet and to the right (in the binder) of the sheet on which appear the yearly averages. This arrangement makes easy the comparison of yearly averages, one with another, and also the comparison of current performance with that of prior months or periods as far back as the beginning of the current fiscal year or with the averages of prior years.

Details of the current percentage of extra compensation earned by a department can be shown on the back of the same form used for the monthly or period figures of the Departmental Analysis. The yearly averages can be posted on the third sheet which completes the line-up for the department. These figures constitute what may be called a "Bonus Analysis" and, of course, will appear only when a department is working on a wage incentive plan.

In an effort to present definite information about a department seldom measured and to further explain the arrangement of the forms that have been mentioned, let us consider an Electrical Maintenance Department. Such a department has been measured and set up on a wage incentive plan by the determination of allowances for the various jobs performed.



Extra Commission Earned, and Bonus Analysis.

Application to Electrical Maintenance

The group that is referred to is part of a moderately large organization with product of a jobbing shop nature. The machine tool equipment is reasonably modern and consists of many expensive machines, some of which are driven by individual motors and others by lineshafts.

The first group of duties of the electrical maintenance men includes the changing of armatures, the replacing of motors with spares, the replacing of motor bearings, the installing of main line switches, the installing of starting switches, the laying of conduit, the installing of lights, the installing of plug receptacles, the moving of automatic telephones, and so on.

The second group of duties includes the making of minor repairs such as the changing of motor brushes, the cleaning of commutators, the replacing of contacts, and the checking of connections. The changing of electric light bulbs, the replacing of sockets, the replacing of plugs, and the lubricating of all motors also are included.

The first step taken in the measurement of the results of this department was to list the duties of the men. Each daily, weekly, or monthly routine job was set down and then a study was made of the various kinds of work that these men were called upon to do as ordered.

The duties and jobs were then analyzed and broken down into the tasks that were required to complete the whole duty or job, and it was necessary to bear in mind that each duty and job had to be broken down in such a way that the final list of tasks would be suitable for use in setting allowances.

One could set down, under the heading of "Routine Duties," the item of "Maintaining All Electrical Equipment" and under the heading of "Special Duties," the item of "Complete Each Order." It is true that those notations would cover the work of the electrical maintenance men being discussed but the items are so broad that they are useless when one is attempting to measure results.

Another item that is more detailed than either of the two already given, but which is still too broad, is that of "Installing Lights." More information is required if the job of installing lights is to be handled properly from the standpoint of determining an allowance for it. The length of conduit used, as well as whether or not push button switches were installed, and details of like nature, have to be known.

After all of the routine duties and special jobs had been analyzed and broken down into the tasks of which they were composed, the list included such items as replacing motors with spares; changing armatures; installing main line switches; installing starting switches; installing resistance; installing conduit and wires; making minor repairs to motors, such as changing brushes, cleaning commutators, replacing contacts, and checking connections; oiling motors; changing light bulbs.

Motor sizes and motor locations were considered as were the difficulties encountered in the installation of conduit. Those jobs that were to be measured by volume were separated from the routine duties.

Having arrived at the basis of measurement for each item, the next problem was that of determining the allowances. This was done by keeping a record of the performance of the men on current work, checking into past history, and studying each item in a way that is similar to the method employed by time study men who set allowances on jobs.

Keeping a record of the current performance of the electrical maintenance men was not difficult because their duties and jobs had been classified. It was simply a case of setting in motion the machinery that had been set up. And that machinery had been designed for the very purpose of recording accomplishment.

The work involved in the checking of past history was not as difficult and as disagreeable as it may sound. The records that could be used were examined for variations in taken time on similar jobs. When these variations were small, only a very little effort was expended in spot-checking over a reasonable period of time. But if the variations were large, a greater effort was made to examine the records farther back and to find cause.

A consideration of past performance is not always necessary as there are many departments and classes of work that do not require such analysis.

A study of each item in the list of tasks was then made by analyzing various physical arrangements and layouts in the plant, and by making detailed observations of the men while they worked. Many of these studies were patterned after the method used by regular time study men but, of course, there was no attempt to split minutes. A set-up of this nature does not require the extreme accuracy that is required by set-ups on other kinds of work.

Through comparison, discussions, and analysis, the final allowances, which were expressed in hours and dollars, were set for each task. They were then applied, over a period of several months, to the work of the department for the purpose of checking everything that had been done. After the test of time showed that the measuring unit was practical and desirable and in smooth running order, it was used as the basis for a wage incentive plan.

Down the edge of the forms used for the "Departmental Analysis," the following items are some of those that were listed:

Standard Hours of Work
Standard $ of Work
Taken Hours
Taken Hours per Standard Hour
Taken $
Taken $ per Standard $
Average Hourly Rate
Bonus $ Paid
Total Cost, Including Bonus
Total Cost per Standard $ of Work.

Attention should be called to a few of the items that have been given, because they are guide points.

The item "Taken Hours per Standard Hour," for example, is one of the more important items. It shows the speed of the group.

The item "Taken $ per Standard $" is another important one. It shows the efficiency of the supervisor and prevents his being tempted to use operators whose salaries are too high in comparison with their efficiency.

The "Total Cost per Standard $ of Work" may be taken as the summary statement of conditions in the department. One glance at the figures opposite this item will give the executive a picture of the trend of the unit cost.

The specific wage incentive plan that was used for these electrical maintenance men is not of such great importance. Almost any one of the prominent systems could have been applied to good advantage if handled properly, so let us pass over that phase of the set-up.

In anticipation of some of the major questions that may arise, let me discuss a few more points.

Let us assume that some one says, "Such a plan may provide an incentive to ease up on the routine duty of oiling motors. This would reduce the taken time of the men but the company would be a heavy loser in the end."

In answer to such a charge, it is necessary that we recall the distinction that was made between "work" and "results" and also recall the importance that was placed on "results" as compared to "work." And then it is necessary to know that a very severe penalty plan was set up to insure good condition of equipment.

One may also wonder about the provision that was made to prevent the supervisor, or the group, from "creating" additional work. Saying the same thing in a little different way, as applied to a specific case, "What prevented these maintenance men from putting up new crane runway wires each day?"

The answer to that question is found in the departmental budget system that is used throughout the organization, together with the practice of charging each foreman with the cost of all maintenance work done in his department. It is necessary that he approve all charges against his department because he is held accountable for keeping his expenses down to the amounts budgeted.

The problem of handling new work not covered by the allowances that had been set did not present any trouble because a great deal of care had been taken to anticipate a reasonably wide variation in job orders. The study of past history gave an excellent picture of the range of work required of these men. If a new job should be ordered, it is likely that the allowances could be used for the greater part of the job. The balance of the work could then be estimated and set up in the regular way. Such practice would be safe because only a small portion of the job would have to be paid for on the basis of an estimate and that small portion would become a still smaller portion of all the work done in a period.

Another question that may arise is this: "Is the expense of setting up such a measuring unit justified by the reduction in cost that takes place in the department?"

The answer must be qualified because the final result depends upon the attitude of the management, the conditions that exist in the organization and department, and the method used in developing the plan. In the department that has been described the savings exceeded the expense of installing and maintaining the method of measurement and the wage incentive plan, for the first year, by a ratio of more than four to one. After the first year the ratio became greater.

Summary

In summarizing, let us remember that some steps can be taken toward lower unit costs without the installation of wage incentive plans. These steps are: (1) the making of an analysis of the department that is not functioning satisfactorily and setting the findings down in good form; (2) holding the department head responsible for good performance as indicated by the analysis.

If wage incentive plans are desired, take the two steps that have just been given and then carry the proposed plans on paper until you are satisfied that they are right. When you are satisfied with them, make your plans effective, remembering that Father Time is a great friend to those who build for permanency.

MAINTENANCE OF ELECTRIC CRANES AND HOISTS

What user and manufacturer must do in maintenance and service that the crane or hoist will deliver most value per dollar invested.

ROBERT W. WALTON

Head, Service Department
Shepard-Niles Crane & Hoist Corporation
Montour Falls, N. Y.

WHILE it might seem that maintenance and service begin only after the machine has been put to work in the user's plant, actually they are major items of design. Ease of lubrication, simplicity, and accessibility loom large in the mind of the inexperienced designer and last, but not least, the provision against the uncanny ingenuity of inexperienced operators to do the wrong thing must be considered. These are points not taught in text books. They are gained only by years of experience and acquaintance with current practice and malpractice in the industries using the equipment.

The user of a crane of 100 tons capacity or more, or the user of 100 cranes or hoists of small capacity, is almost sure to have a trained force of mechanics and electricians capable of coping with any maintenance problem likely to arise and such large users also are likely to have individual operators who are taught proper methods of operation. Lubrication, inspection, and instant correction of bad adjustments are major duties in plants where synchronized quantity production depends upon the proper functioning of all handling equipment. Such plants often have men constantly patrolling their conveying lines. By means of call stations, bells, and signal lights similar to a city fire alarm system they can have a maintenance man on the job in less than a minute, or on a general alarm a gang of a dozen men can be concentrated in one point in less than three minutes. A delay of three minutes on an automobile assembly line turning out several thousand cars a day is a misdemeanor and a longer delay is almost a capital offense and insures the maintenance foreman a session on the carpet.

These larger plants make few calls on the service departments of manufacturers of reliable equipment except when the original installation is being made, or a new problem being worked out, but when they do need help their need is in proportion to their size and the prompt assistance of specialists thoroughly acquainted with the handling equipment and experienced in adapting it to varying conditions is invaluable.

The small user of only a few handling units usually cannot provide a trained maintenance force. His plant operations may not be such as to acquaint his men with electrical equipment. His cranes or hoists are likely to be handled by any one who takes the fancy or by men interested only in the quantity of material handled, and adjustment and lubrication of the hoisting equipment probably occur only when some one is divinely inspired, or when the machine begins to slow down. Their notion of the cause of any trouble is likely to be hazy and their reports sketchy, but a manufacturer with a well organized service department equipped with data gathered over years of experience can often suggest a solution to the trouble, or can dispatch a trained mechanic on a moment's notice and save his customer heavy loss from interruption of production.

Electric cranes and hoists probably vary more widely than any other machine manufactured, but they have some common points. They all have one or more motors and some kind of starting mechanism. These motors and controllers or starting boxes usually require more attention on cranes than does similar equipment in other installations, due to the fact that they are used more often. A hoist motor gets two starts and two stops on each operation. The second start is a reversal and may represent more or less plugging. One such installation has trolley motors which work on a four-second cycle and to make it worse the operator plugs the motor to spot his load. Daily inspection of slip-rings, controller brushes, and contacts, and frequent renewals are necessary on such operations.

All controllers should receive periodic inspection, all dust should be blown out, the contacts and brushes should be kept smooth and free from "bugs" or fused spots, the contacts should be lubricated with vaseline and the bearings oiled. Controller ropes on floor controlled machines should be renewed before they become frayed and only wooden handles should be used on these ropes, because heavy metal handles hanging about the height of a man's head may cause serious accident.

Good housekeeping is worthwhile in any plant and especially with the electrical equipment of cranes and hoists. Dust may lodge between commutator bars and finally ruin a motor. Metallic dust in a copper plant caused no end of trouble in this way, notwithstanding very good maintenance.

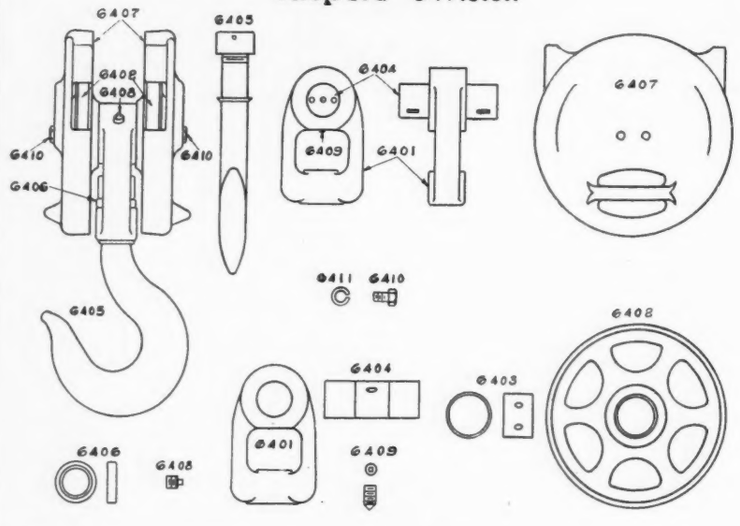
It is better to turn down burned slip-rings in a lathe

2020

Shepard Niles Crane & Hoist Corporation

MONTOUR FALLS NEW YORK U.S.A.

Shepard Division



LOAD BLOCK

Part Number	Number Required	Title
6401	1	Lower Block Frame
6402	2	Lower Block Sheave with Bushing
6403	2	Lower Block Sheave Bushing
6404	1	Lower Block Sheave Pin
6405	1	Lower Block Hook with Collar
6406	1	Lower Block Ball Bearing
6407	2	Lower Block Cable Guard
6408	1	Lower Block Frame Pipe Plug
6409	1	Cup Point Set Screw for Part #6404
6410	2	Cap Screw for Part #6407
6411	4	Lockwasher for Part #6410

WHEN ORDERING PARTS ALWAYS SEND THE SERIAL NUMBER OF THE HOIST WHICH APPEARS ON THE BRASS NAME PLATE FASTENED TO THE GEAR END (PART #6418)

BULLETIN SHEET-20

Sheet 2020 — Typical individual spare-part bulletin. Size 8½x11 in.

than to stone out the burned spots, because low spots formed by stoning may make a brush jump and start the burning all over again.

Nearly every crane and hoist has some sort of electrical conductor and collector. No matter how well these conductors are installed, or collectors designed, they are not as good as solid electrical connections and poor contact due to dirt, ice, corrosion or loose connections is the source of most electrical trouble on cranes. This seems to be especially true on the secondary circuit of alternating current cranes.

Pickling plant service is especially hard on all electrical equipment, because the acid fumes attack insulating material, and corrode conductors and control apparatus. It is practically impossible to provide covers at all vulnerable places, or to make covers tight enough to keep out the corrosive fumes. Probably a heavy coat of common cup grease is about the best protection.

All cranes and hoists have some type of gearing. Proper attention to lubrication is about all that is necessary with these parts. The manufacturer's instruction as to the type of

INSTRUCTION DATA

Wiring diagrams for this equipment will be found in a water proof envelope attached to the shipping crate.

ONE SPARE PART BULLETIN giving part numbers, maintenance, adjustment and oiling instructions, and additional wiring diagrams will be mailed to the shipping address appearing on the acknowledgement immediately after the apparatus is shipped **unless** we are instructed to the contrary.

YOUR MAINTENANCE MEN should have access to this information and if you desire an additional bulletin it will be mailed free of charge.

Please fill out and return the attached slip.

Shepard Niles Crane & Hoist Corporation's Order _____

Customer's Order _____

We desire Spare Part Bulletins, addressed for the attention of:

Mr. _____ Title _____

Address _____ Street _____

City _____ State _____

Mr. _____ Title _____

Address _____ Street _____

City _____ State _____

Signed _____

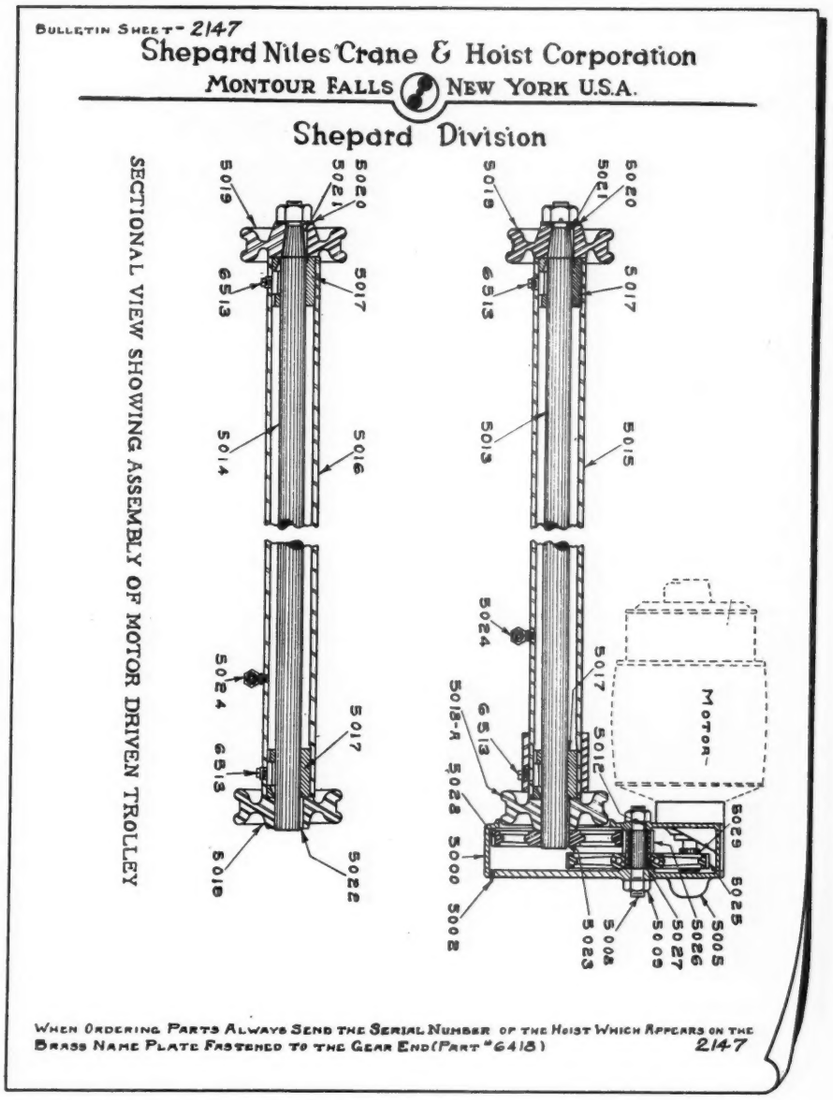
Address _____

_____

Form 126—Mailed to customer by manufacturer with acknowledgment of order.

lubricant should always be followed; grease should never be substituted for oil in bearings designed for oil lubrication, or vice versa. The best quality of oil obtainable, providing it is of the proper character for the bearing, is the most economical, no matter what its price, because the savings on cheap oil will be swallowed up many times in the cost of repair parts and shutdowns.

Hoisting cables should receive special attention, because they probably are more exposed to injury than any other part of the machine and their failure is very likely to result in fatal accidents. They should be well lubricated with a heavy oil or special cable lubricant, should be kept in the groove of the drum, should be inspected regularly, and should be renewed as soon as they show signs of wear or have many broken wires. So much depends upon the conditions surrounding the service that no definite rule can be given which will enable an inexperienced person to decide whether or not a cable should be replaced. Possibly a good general rule is to replace a cable if it has six or more broken wires per foot, or three adjacent broken wires in the same strand, or if the outside wires are worn one-third through and no wires are broken. One foundry concern tests all cables with a 50 per cent overload once a week. Cables used over pickling vats should be kept well coated with lubricant due to the fact that the acid may attack the steel and make the wires brittle without producing any difference in the appearance of the cable. The brine in ice plants also destroys cable rapidly by corrosion if the cable is not well covered with lubricant.



Sheet 2147—Typical individual spare-part bulletin. Size 8½x11 in.

Cable collars and sockets should always be put on in such a way that the strands do not become untwisted or be subjected to unequal tension just below the collar. The hemp center should be cut out and the ends of the strands turned inward and thoroughly soldered to the socket with half and half solder. Turning the ends of strands inward is essential; cables with the strands turned outward or not turned at all are likely to pull out of the socket.

Electric brakes, foot brakes, mechanical brakes, and limit stops are features peculiar to each design and the manufacturer's printed instructions form the best guide to their maintenance.

Electric brakes and foot brakes must be set so that they are entirely free when the brake is in the released position, but at the same time the air gap of electric brakes must be kept small enough so that the armature or movable part will always be lifted when the current is on. Otherwise the motor works against the brake as well as the load, and may burn out. Too wide an air gap on an a.c. brake will almost surely burn out the brake coil.

The arrangement of the phases on the conductors for three-phase machines sometimes is not checked up with the result that motors are reversed and the limit switch becomes inoperative and an accident may result from the hoist being run block to block. Improper phase relation on a two-phase, three-wire system may result in burned out motors.

Traveling cranes, of course, use crane runways and poor runways out of line with varying spread make proper crane operation impossible. The inspection sheet, marked Form 186, sent out by my firm to encourage regular inspection of cranes by its customers, assumes that inspection will begin with the runway and conductors.

The location of the bumpers at the ends of the runway deserves attention, for every crane must be squared up on the runway occasionally. A service man was called recently to investigate a crane that worked hard. He found that one bumper had been moved and the crane was actually being bumped out of square every time it was run against the stops.

Form 186 2M 4-29

Shepard Niles Crane & Hoist Corporation

CRANE INSPECTION REPORT

Crane No. _____ Type _____ Hoist Serial _____

Inspected by _____ Date _____

KEY WORDS—OK. G = Good: F = Fair: W = Worn: A = Need Attention: C = Need Cleaning· T = Too Tight

RUNWAY and CONDUCTORS

Track Alinement _____ Spread _____ Fastenings _____

Line Conductors _____ Conductor Supports _____

TRUCKS and MAIN COLLECTORS

Truck Wheels, Flat Spots? _____ Flanges _____ End Play _____

Axle Bearings _____ Lubrication _____

Truck Drive Bearings _____ Lubrication _____ Gears _____

Gear Screws _____ Pinion _____ Key _____ Collectors _____

GIRDERS and DRIVE

Drive Shaft _____ Couplings _____ Bearings _____ Lubrication _____

Foot Brake Shaft _____ Couplings _____ Bearings _____ Lubrication _____

Bridge Brake Case _____ Adjustment _____ Lubrication _____

Walkway _____ Railing _____ Ladder _____

Bridge Motor Support _____ Shaft Extension _____ Couplings _____

Bridge Drive Gear Case _____ Gears _____ Lubrication _____

MOTORS

Location	Armature or Rotor	Commutator or Slip Rings	Brushes	Brush Holders	Bearings	Lubrication
Bridge						
Hoist						
Aux. Hoist						
Trolley						

Trolley Wheels _____ Trolley Wheel Bearings _____ Lubrication _____

Trolley Gear Case _____ Case Support _____ Gears _____ Lubrication _____

Hoist Gear Case _____ Main Gear Train _____ Comp. Train _____ Lubrication _____

Mech. Brake _____ Drift * _____ Elec. Brake _____ Adjustment _____ Lubrication _____

Drum _____ Cable _____ Cable Pin _____ Limit Switch _____

Limit Switch Adjustment _____ Hook _____ Sheaves _____ Lubrication _____

Trolley Conductors _____ Trolley Collectors _____ Cage Roof _____

Door _____ Windows _____ Foot Brake Treadle _____ Cont. Levers _____

CONTROLLERS

	Brushes	Brush Holders	Contacts	Wiring	Springs	Resistance	Screws Tight
Bridge							
Hoist							
Aux. Hoist							
Trolley							

* The load should come to rest, from full speed lowering, almost instantly when the controller is centered

Form 186—Inspection sheet, distributed by manufacturer to encourage regular inspection. Size 8½x11 in.

The condition of monorail tracks also is worthy of consideration, especially if curves exist. Some years ago when monorails ran infrequently and at a top speed of about 250 ft. per min., an ordinary beam flange served very well as a monorail track, but under modern conditions, with cage- or pulpit-controlled machines of several tons capacity running at 400 to 600 ft. per min., these beam flanges peen down rapidly. In one automobile plant monorail beams had to be turned over or renewed about every month and relief was obtained only when rails were added to the bottom flange of the beams.

Engineers and purchasers are continually asking how small a curve a monorail will negotiate and there is a temptation for hoist builders to encroach on safety and good operating conditions at this point. While curves are convenient and often necessary, the fact is that any curve is undesirable, though curves with quite small radii can be used if the customer is willing to pay the penalty in worn trolley wheels and trackage. Every curve should be made as large as possible, especially if high trolley speeds are required.

Equipment is built so well nowadays that it seldom fails under normal conditions. Motors seldom burn out, gears fail, or cables break, unless there is a cause. This cause often is hard to locate, especially from correspondence. Long experience has induced the habit among service men of suspecting lack of lubrication first, partly because it is such a minor consideration with some users. A user recently stated that he was overhauling his plant and had a hoist that had received no attention for about two years. He wondered if it would be all right to change the oil. He was told to go ahead, as probably the hoist would stand the shock. Another small hoist which, as the owner said, was getting slow, was examined. It was worse than dry; there was a heavy residue of oil in the gear case which had to be scraped out. One motor oil pipe was knocked off and a wooden plug was driven in its place.

Another hoist was returned by a large manufacturing firm with the report that after two years it suddenly broke down. On opening the machine it was found to be dry. Bronze bushings with $\frac{3}{16}$-in. walls were worn entirely away, one gear pin an inch in diameter was worn two-thirds through. Yet, apparently, the man making the report honestly believed that the hoist was always properly lubricated and suddenly failed after running two years.

Next to lubrication perhaps comes side pulling. Hoists are supposed to lift vertically, but some users seem to forget that. Kosher butchers hook a beef by the hind leg, start the hoist, and the beef finally does a sort of head spin on the floor, and meanwhile the hoist has been pulling from all angles. Kosher butchers are not supposed to understand machinery and they can be forgiven when we find a large manufacturing concern using a monorail hoist and two transfer cranes to pull railroad cars on tracks running diagonally under the crane runway. Only their purchase of crane axles and bearings aroused the suspicion of the crane builder and led to the discovery of the ingenious scheme. The manager of the plant vetoed the arrangement instantly when it was called to his attention.

It is so convenient to use a crane or hoist to drag objects along the floor, beams out of a pile, or to turn something over, that the practice probably will persist, no matter what crane and hoist builders say about it. However, the users should know that they must pay for the convenience in injury to drum grooves, rapid cable wear due to piling, broken limit switch levers, burnt cables due to their coming in contact with conductors, skewed cranes, and strained runways.

The question of whether the maintenance of cranes comes under the electrical or mechanical department of a plant is one that each plant must decide for itself. Some plants place the electrical part of the crane under one department and the mechanical part under another. This arrangement often leads to a fine game of buck-passing and there is great danger that the limit switch, electric brake, or some other feature on the border line will fall into "No Man's Land" and be neglected by both departments.

Recently the rear motor bearing of a new monorail hoist, in a plant having dual maintenance control, fell in the disputed territory and had been neglected for several months. Fortunately a service man from the factory happened along and called attention to the bearing. A few more weeks of neglect probably would have resulted in a real repair bill and the maker of the machine never would have gotten at the cause of the trouble.

Production nearly always depends upon the proper functioning of cranes and hoists and their maintenance is vital. It is better to make one man or department responsible for their upkeep and have him requisition help from other departments, if necessary, than to attempt the policy of dual control.

Even with the best maintenance organization possible the user of cranes and hoists, on account of their highly specialized construction, is compelled to rely to some extent on the crane manufacturer for information on details, hints on maintenance, spare parts, and service.

All reliable companies feel a responsibility for every machine as long as it is in operation, and must keep records that will make identification immediately possible. Consider our procedure, for example. We keep a card index based on the serial number, another index based on the customer's name, one on the motor serial, one on the controller serial, and one on the crane serial.

At the time the hoist is shipped we attach a waterproof envelop to the shipping crane. This envelop contains a wiring diagram, a sheet on adjustment of the electric and mechanical brakes and, in cases of switches and conductor material, erection instructions for these parts.

A spare part bulletin is mailed immediately after the machine is shipped. There are two general classes of spare-part bulletins. One consists of a tabulated catalog showing general illustrations of the line produced by the manufacturer and giving lists of all parts in each type of machine. The other is an individual spare-part bulletin made for each machine. Each part is designated by conventional name and number, which are kept constant for the same part in different sizes of machines. It is only necessary for the customer to look up the serial number of the machine, select the part from the bulletin applying to that machine, and order by part number and name.

Sheets 2020 and 2147 are typical spare-part bulletins.

Bulletins as described are always intended primarily for the customer's maintenance force but there is difficulty in getting them into the hands of the right men. Mailing the bulletin actually works better than attaching it to the hoist. In an effort to get the bulletin into the hands of the right men, Form 126 is sent along with the acknowledgment of the order.

Promptness and accuracy in filling repair orders is recognized by every reliable manufacturer as one of the best services he can offer and the customer can help greatly in this by always specifying the serial number of the machine and using the correct names and part numbers in his orders.

■

Truck and Skid Handling

C. C. STUBER

Department Manager, The Goodyear Tire & Rubber Company
Akron, Ohio

(Presented at the Trucking and Shipping Session)

WE unload 80 freight car-loads of raw material daily. We have a personnel of 753 serving our craftsmen over a floor space of 6,443,419 sq. ft., delivering material with a fleet of 15,337 electric trucks, hand trucks and platforms, and using 86 elevators. Revolving independently are some 29,000 ft. of electric and gravity conveyors. Such a tremendous capital investment must be economicaly and efficiently handled, and what industrial transportation cannot be eliminated becomes a part of the manufacturing process.

All transportation suppliers' wage earnings are computed on a piecework basis. When material is delivered to a department for use of the department's craftsmen, the supplier distributes his load in such a way that all craftsmen will be kept busy. The supplier's incentive, of course, is that, operating on piecework himself, the greater amount of material the craftsman consumes, the greater will be his own earnings.

Accounting Control—The cost of transportation service is charged directly to the production division from which material is being transported. Industrial transportation equipment is divided into 44 classes, and a code number is set up for each class. All repairs, lubrication, and depreciation are charged directly against a class or code. Industrial transportation equipment is allocated according to production departments, and truck maintenance is charged to the production division according to such allocation.

Control of equipment—Industrial truck equipment throughout the factory is controlled and operated under one centralized authority. Centralized control will route deliveries so as to have a return load at all times.

A standard type of running gear or chassis was designed with the utmost flexibility in steering and turning through narrow aisles and around sharp corners.

Where material is consumed slowly, the platform-skid method of transportation is adopted. A standard skid height is maintained in order to obtain a flexible service unit. When it is necessary to move skids a short distance only, it is economical to equip skids with casters or wheels.

Considerable experimental work has been done to determine the right type of wheel construction, especially the best width, as floor maintenance seems to be exceedingly high.

MAINTENANCE TOOLS AND EQUIPMENT

Minimum consumption of time in transporting equipment and in getting men and materials to breakdowns is brought about by the use of trucks designed for just those purposes.

THOMAS A. KEEFER

Head, Factory Layout Department
The National Cash Register Company
Dayton, Ohio

IN DETERMINING the tools and equipment best suited for maintenance departments there must be considered the size of the company, its community, and its management, for these factors govern the standard of maintenance work required. Then comes the product manufactured, which determines the kinds of machinery and equipment to be maintained.

The number of departments and floor space covered must be kept in mind; loss of time in traveling from one location to another costs real money.

The proper numbering of all motors, machinery and equipment is essential in making trouble calls.

How foolish and expensive it would be to work for years in building up a high production standard, in the way of modern machinery, day work, piece work, or group bonus work, and then not employ the most modern and efficient methods in handling quick repairs and maintenance work in the shortest possible time. Equipment out of commission may mean the loss of the time of one man, a group of men, a whole deaprtment, or the entire factory.

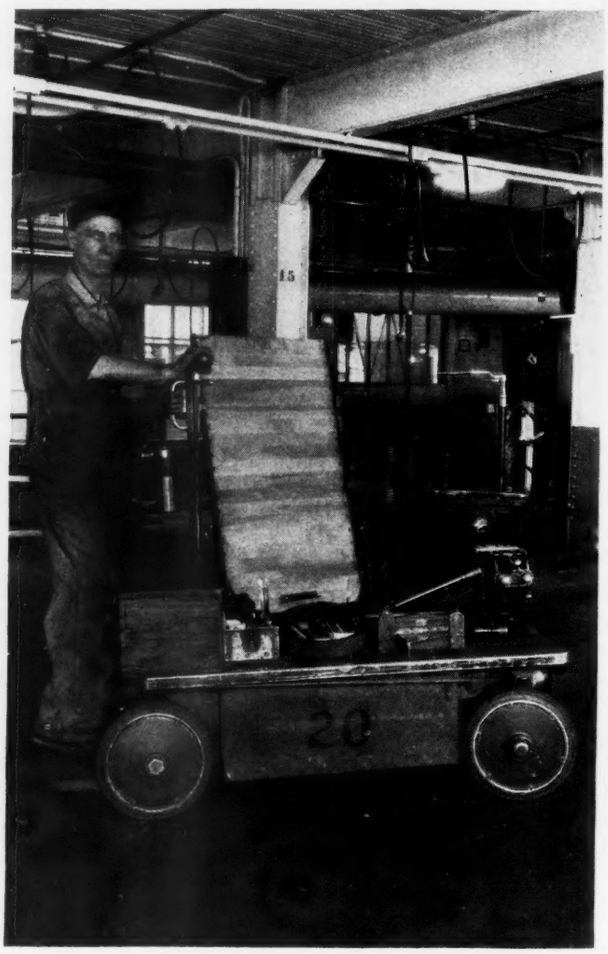
It is important that all maintenance men be equipped with the proper tools, in first class condition, that they may do their work in the quickest time. Two savings result: first, in time required to restore the equipment to running order; and second, in the number of men required in the maintenance department.

The National Cash Register Company has attempted to adopt efficient methods and tools for the maintenance departments. We realize that money paid out because of improper tools and loss of time must be charged to overhead, and under present entrenching conditions the maintenance division must be held under the closest of supervision.

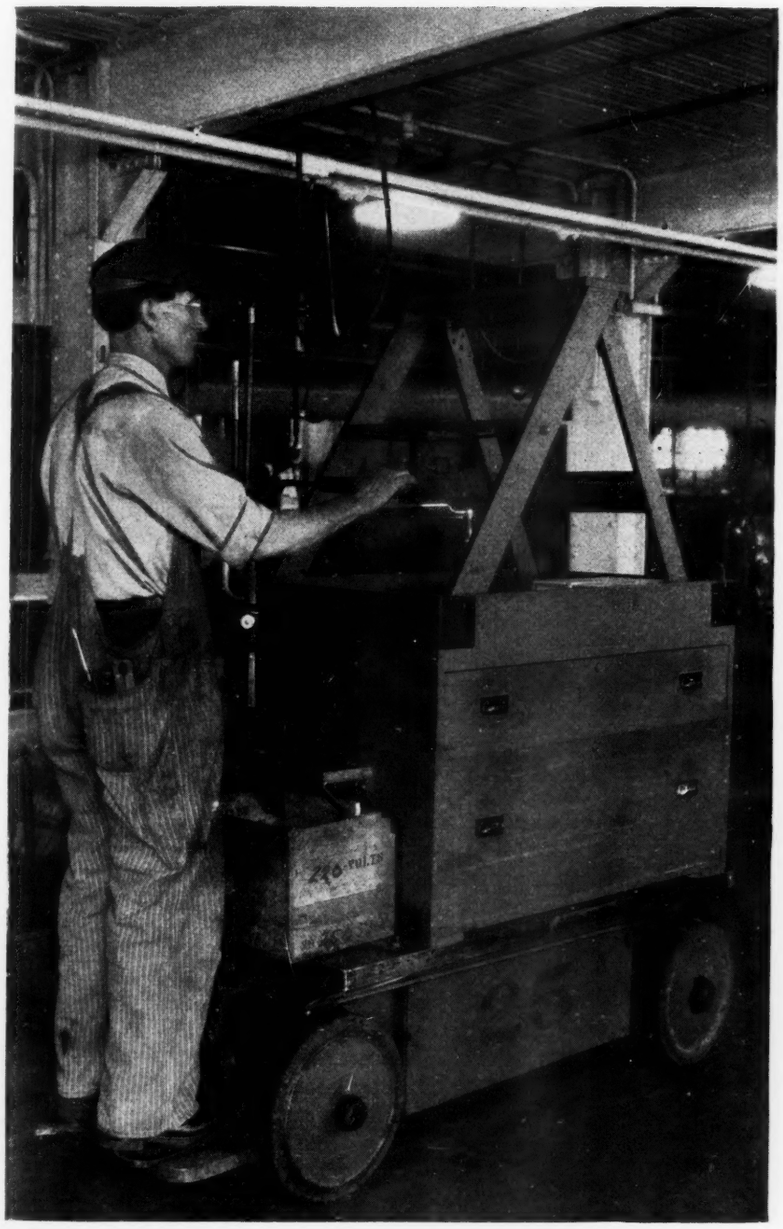
Our slogan is and has been for several years, "Put it on wheels," and this method is followed religiously. Several special kinds of trucks have been designed and built to meet our wants.

I have in mind a special truck for moving punch presses. With the aid of this truck two men can load a 2-ton press and move it from one department to another in one-fifth the time formerly required by the method of disassembling and moving parts, or by moving press intact on rollers.

Lighter machines, such as screw machines, milling



Repairs to and maintenance of belts are handled by men on small, special electric trucks, each equipped with a belt lacer and tools.



A small, speedy electric truck for trouble men in the electrical department. Drawers contain materials and tools for quick repairs. The folding ladder enables the workman to reach ceilings.

machines, lathes, shapers, and small presses, are moved on a specially built, inclined truck, which is 6 ft. long, with standard truck wheels and handle mounted on the front end, and two small-diameter wheels on the rear end. The truck tapers down to within 4 in. of the floor. On the rear end an 18-in. gate, tapered down to a sharp edge, is attached by hinges. This gate can be lowered to the floor, to complete the taper side of the wedge that the truck and the factory floor thus form. On the front end of the truck is mounted a ratchet windlass with steel cable and hook, to be used in loading and in holding machinery in place on the truck during transportation. The end gate is thrown up out of the way when not in use. There are very few machines that cannot be handled by two men, thus cutting labor costs approximately 80 per cent.

For larger and bulkier machines, a 4-wheel truck with sturdier platform is used. Wheels are 6 in. wide and 8 in. in diameter, and are equipped with ball bearings. The capacity of these trucks is between 6 and 7 tons. When a machine is to be transported it is raised to the proper height, then the truck is rolled into position, and the machine is lowered to the truck and fastened there. An electric truck is used to provide motive power. The only saving in this set-up is in the speed and safety with which machines can be moved.

Millwright repair work is handled in gangs of two; each gang of men has a large electric truck loaded with the necessary tools and equipment. Trips back and forth to the shop are eliminated as these men call the maintenance department offices and are directed by some one in charge to the next job. The savings may not be so great, but the prompt service rendered is worth considering.

Repairs to and maintenance of belts are handled by men on small, special electric trucks, each equipped with a belt lacer and tools. A small supply of the different sizes of belting is stored in locked cupboards in all shop departments to eliminate trips to the main stock room. Before the adoption of the belt truck, five and sometimes six men were required to handle this work; now three men can handle around 40,000 belt repairs in one year's time.

The special electric truck for trouble men in the electric department is small and speedy. The body contains two drawers, in which materials and tools for quick repairs are carried. On top is a folding ladder which enables the workman to reach the ceiling on practically all floors. After he leaves the electrical department he phones in to receive instructions as to where to go and what to do on the next job. We have found that one man on a truck of this kind can handle as many trouble calls as two men on foot. Tiering machines are a great help in raising shafting, motors, drives, and other equipment which is hung from the ceiling.

Power hand saws have proved to be labor-saving tools. They are used in rebuilding benches and stock bins, cutting off flooring when patching, and on other jobs where the material cannot be cut in the mill.

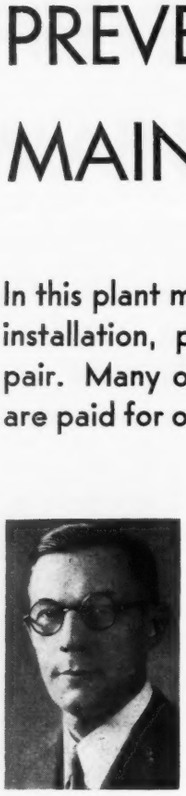
Portable electric drills and hammers are used quite extensively in cutting holes in floors and ceilings.

We have adopted the hand-saw filing machine. Our carpenters prefer a saw filed by machine, and report that machine-filed saws cut much better.

Under present curtailment orders not only is it necessary to do maintenance work by the speediest methods, we must always be on the lookout for time-eliminating methods, supplies, and equipment.

INSPECTION FOR PREVENTIVE MAINTENANCE

In this plant maintenance includes selection, installation, prevention of breakdown, repair. Many of the maintenance operations are paid for on an incentive basis.



AUGUST HECKMAN

Superintendent Buildings, Light Heat and Power Department

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

IN MANUFACTURING plants the accepted definition of "Maintenance" is, "The keeping of buildings and equipment in repair or in operating condition." Because production so greatly depends on maintenance, we broaden that definition to include not only this meaning but also three other points: first, that of careful selection; second, proper installation; and third, prevention of breaking down of equipment.

The placing into operation of this broadened idea of maintenance is the function of that part of our organization known as the Buildings, Light, Heat and Power Department. In order to expedite the work of this department it is divided into five main divisions, namely, Works Engineering; Power Plant; Buildings and Grounds Maintenance; Light, Heat and Electrical Equipment Maintenance; and Plant Planning and Layout.

The three additional phases to the definition of maintenance will now be discussed. First, the careful selection of equipment is made in the works Engineering Department by men who are specialists along their respective lines, and who work in conjunction with the various superintendents before arriving at any definite decisions. Second, the proper installation of the equipment is done by the two Maintenance Departments in line with the instructions of the Works Engineering Departments. Practically all installations are governed not only by state laws but by rules formulated by our Plant Safety Committee.

We now come to the third point, the prevention of breaking down of equipment. Of vital importance is the adoption of preventive measures in trying to anticipate troubles by eliminating potential sources of failures, hazards, and interruptions in service by careful inspection of the equipment. One important factor in the accomplishment of this result is the aid of our maintenance inspectors. (See accompanying organization chart.) These men make general inspections of buildings and grounds, and detailed inspection of the following equipment: cranes, trolley wires; crane runways; electric hoists, air hoists; chain blocks; special lifting devices; slings made from chain, manilla rope, and wire rope; elevators; hydraulic pumping stations; conveyors; all new electrical installations; electrically heated apparatus, such as solder pots and ovens; wire enameling towers; ventilating systems for ovens, acid hoods, lavatories, offices, dust collectors, and paint spray booths; air blast blowers; vacuum suction systems; shot blast machines; gas-heated furnaces; all piping for steam, air, gas, and water; police and fire alarm systems; and power plant switching units. This list is mentioned to give an idea of the varied equipment upon which we endeavor to anticipate breakdowns.

In addition to the regular maintenance inspectors, all the maintenance foremen and supervisors act as inspectors and report anything which may cause interruptions in service even though that particular branch of work may not be under their direct supervision. Similarly, all general inspectors in the production departments report to the general inspector of the maintenance department items which are hazardous or which may hinder production.

It has been the company policy to permit the workmen to meet with the management in a committee which we call the Works Joint Conference Committee. This body appoints a sub-committee known as the Shop Regulations Committee, the latter consisting of several supervisors and several of the workmen. This sub-committee makes periodic inspections of the shop and submits recommendations to the management. These recommendations are primarily an aid in the keeping of the shop in a clean and orderly condition. Naturally, the report covers a number of points which, if not corrected, would cause

accidents, fires and breakdowns of equipment. This form of inspection is very desirable and has the support of the workmen.

Reports

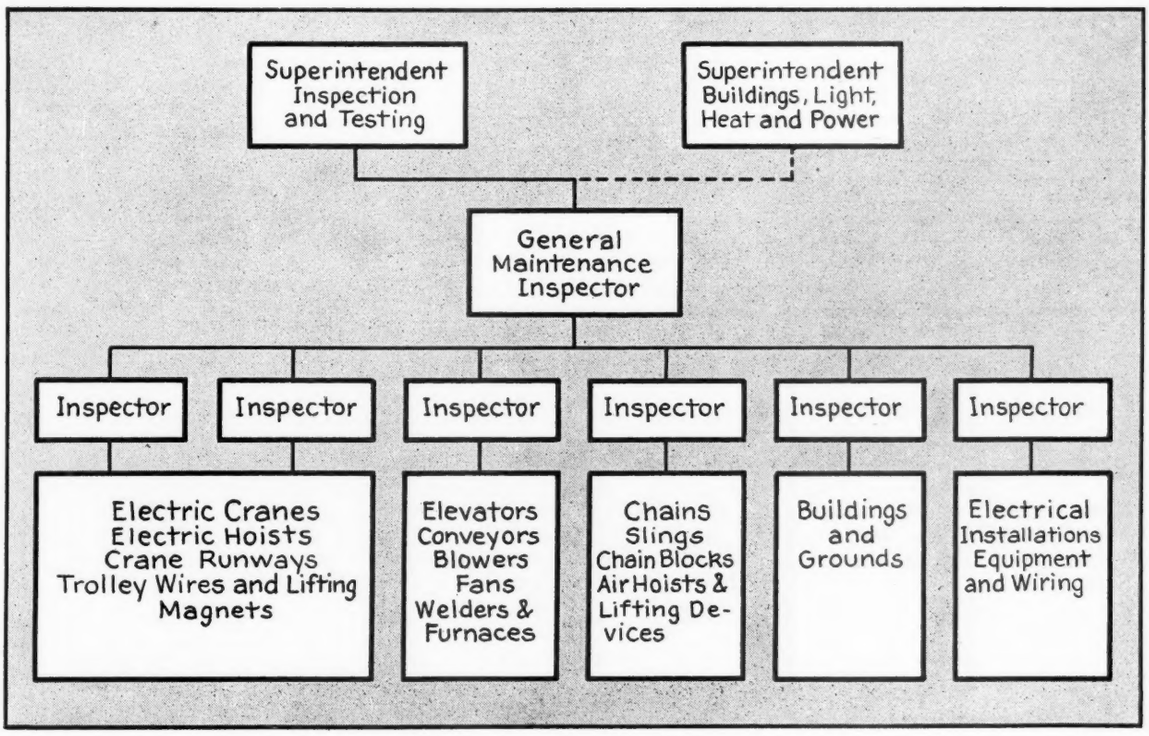
Maintenance inspection, to be effective, must be continuous, and all items listed for inspection should be checked at periodic intervals. All findings and recommendations made as a result of the inspection should be noted on forms provided for that purpose. These forms may either be printed or mimeographed, depending upon the number required. As a guide to the inspector and in order that the inspection be carried out in a complete manner, the forms should enumerate as many of the points to be covered as is feasible. Typical examples are those covering cranes, elevators and conveyors. (See accompanying illustrations.) These reports, in duplicate, are sent to the repair department for information and guidance. By this method the majority of troubles are caught before becoming serious or dangerous. These inspections, however, do not relieve those operating the equipment from their responsibility for reporting any trouble or fault with the equipment during the interval between inspections. The reports are kept on file, not only as a matter of record, but to check the frequency of a recurring condition. They also help in checking the work of both the operators and the repairmen.

One of the most important functions of any inspection set-up is the prevention of accidents which might result in injury to workmen or damage to material. This is particularly true where overhead traveling cranes or hoists are used. This type of equipment uses either wire rope or chain. The application of each of these is dependent entirely upon the use to which it is put. Wire rope can be easily inspected, and should be examined at least once a month. Chains, however, do not present such an easy problem, because a visual inspection is not sufficient to determine whether or not the chain is safe. Not all users of chains agree that chains should be annealed and those who do believe in annealing do not agree as to what is the best method and what are the proper temperatures. We have tried a number of methods and also various temperatures.

Chains

On account of several chain failures the management appointed a committee to investigate our chain situation and submit recommendations. After visiting a number of plants in the Pittsburgh district they found that no two companies had the same method of handling chains; that is to say, different materials were used, as were different methods of heating and cooling, different types of furnaces, and different tables of safe loads. What particularly impressed the committee was the fact that no plant, including our own, had any means of testing the chain after it has been repaired and annealed. As a result of the investigation the committee recommends, among other things, that all chains be made of the best grade of Swedish iron, annealed at a temperature of between 1325 and 1375 deg. F., and subjected to a proof test. It was determined that the purchase and installation of proper forging facilities, an annealing furnace, and a testing machine would necessitate the expenditure of approximately $65,000.

Although the committee realized that this equipment would not be used sufficiently to warrant such a large expenditure, they knew that the work should be done for safety reasons. In order to obtain the desired results, it was recommended that all chains be sent to a chain



Organization for maintenance inspection

Form 3830-B
W. E. & M. Co.
Works Dept.

ELEVATOR INSPECTION REPORT No. 43

Elevator No. 61 Section 2-10 Date 2-10-31 Inspected By T. Mooney

- ☐ M. G. Set —
- ☐ Motor Carbons short, need new ones
- ☑ Controller 3 Contacts burnt
- ☐ Selector —
- ☑ Brake
- ☑ Slack Cable Device
- ☐ Automatic Machine Limit Lock nut loose
- ☑ Worm
- ☑ Worm Gear
- ☑ Drum
- ☐ Governor and Cable Cable has a few broken wires
- ☐ Car Not clean
- ☑ Car Master Switch
- ☑ Car Emergency Switch
- ☐ Floor Landing Switch —
- ☐ Inductor Switches —
- ☐ Landing Cams —
- ☐ Push Button Control —
- ☑ Car Gate
- ☑ Annunciator
- ☑ Signal Bell
- ☑ Trailer Cables
- ☐ Guide Shoes One bolt loose in bottom s
- ☑ Safety Plank done
been insp
good cond
- ☑ Hatchway

Landings 2 bolts loose in 3rd floor lock
One slat broken in 1st floor door

- ☑ Lifting Cables
- ☐ Compensating Cables —
- ☐ Counter-weight Cables 2 Wires broken in one cable
- ☑ Operating Cables
- ☐ Secondary Sheave —
- ☑ Operating Sheaves
- ☑ Car Guide Rails
- ☑ Counter-weights
- ☐ Counter-weight Rails Bolt loose in pit
- ☑ Buffers or Bumpers
- ☐ Pit Not clean

General Condition of Elevator Fair

Elevator inspection report. Like the crane report, it is sent to the repair department

manufacturer (located within three miles of our East Pittsburgh Works) for repairs, annealing, inspection, and proof testing, because that company was equipped with the proper facilities. Therefore, our management contracted with the chain manufacturer to do this work and to furnish us a separate certificate for each chain. All crane chains are tested and annealed at least once every two years except in cases of severe usage where testing and annealing are done at least once a year. All sling chains are tested and annealed from one to four times a year, in accordance with the judgment of the chain inspector, who is guided by the usage of the sling chain. This set-up has given very satisfactory results as is demonstrated by the fact that during the past two years, with approximately 3,000 chains in service, we have not had a single failure except those which were due to overloading.

Zoning

Our Works at East Pittsburgh has been divided into zones serviced by twenty repairmen who anticipate and repair all electrical troubles. During the periods between actual repair jobs they inspect all electrical controllers, motors, push buttons, switches, and other electrical appurtenances. Any part which may cause a failure is repaired or replaced at that time. This set-up has proved very efficient, and the result of our efforts can be best illustrated on several items by representative figures which were compiled over a period of three months. On 198 cranes and 267 electric hoists, or a total of 465 units, we received only an average of 12 trouble calls per day; on 48 freight elevators and 10 dumbwaiters, 3 calls; and on 7,600 machine tool motors, 52 calls. It should be kept in mind that every motor has a switch and that the majority of them have additional auxiliary equipment such as controllers, resistors, and push but-

tons. Although the trouble calls may appear to be many, they are, in reality, comparatively few, considering the total number of units in the entire installation.

Lubricating and cleaning of all electrical and mechanical equipment, excepting machine tools, which are taken care of by the machine tool operators, are the responsibilities of one section in the maintenance department. Our experience has shown us that one man can properly carry out these operations on approximately 700 units. On this basis our shop is divided into zones, one oiler being stationed in each zone.

It is apparent that certain pieces of equipment do not require as frequent oiling and cleaning as others, depending on the kind of manufacturing operation, speed of equipment, and type of bearing. Oil-ring bearings on high-speed countershafts require attention once a day, while certain ball bearings require attention once every three to six months. Although it is necessary to oil some bearings daily, some semi-weekly, some weekly, and others at longer intervals, it is good practice to have the oiler see every unit at least once each week regardless of the frequency of lubricating and cleaning required.

Motors on woodworking machinery should be blown out at least once a week to eliminate fire hazards. Those located in foundries, forge shops, and similar places, where they are exposed to abrasive dust, likewise should be blown out at least once a week. In general, this operation should be carried out approximately once every month, except in cases previously mentioned or where dustproof or vapor-proof motors are used. Motors of these types should be opened at least once every six months for examination.

All cranes are cleaned and lubricated by the cranemen. A few are oiled and cleaned during regular working hours, but the majority of the work is done on

Form 6798-C W. E. & M. Co.

CRANE INSPECTION REPORT NO. 124

CRANE NO. 44 SECTION R DATE 2-2-31 INSPECTED BY A. W. Baker

CAGE: ✓

CONTROLLERS: Bridge ✓ Trolley ✓ Main Hoist ✓ Aux. Hoist One loose finger, third from bottom, left. Panel Fuse clip loose. One arcing tip burnt, main contactor.

RESISTORS: Bridge ✓ Trolley One terminal burnt. Main Hoist ✓ Aux. Hoist ✓

BRIDGE: Motor One carbon brush too short. Foothrake ✓ Shafts and Bearings ✓ Gears ✓ Track Wheels One flange of driver track wheel is cutting cage end. Trucks ✓ Walk ✓ Guards ✓ Girders ✓ Bumpers ✓ Main Collectors ✓

✓ denotes that part has been inspected and found in good condition.

MAIN HOIST: Motor Shafts and Bearings ✓ Gears Motor pinion meshing it Sheaves and Block ✓ Chain ✓ Drum ✓ Guards ✓ Beam ✓ Limit Switch ✓ Mechanical Brake ✓ Dynamic Brake ✓ Motor Brake ✓ Intermediate Brake ✓

AUX. HOIST: Motor ✓ Shafts and Bearings ✓ Gears ✓ Sheaves and Block One sheave requires grease. Cable ✓ Drum ✓ Guards ✓ Beam ✓ Limit Switch ✓ Dynamic ✓ Motor Brake ✓

TROLLEY: Motor ✓ Shafts and Bearings ✓ Gears ✓ Trucks and Wheels Flat spots worn in head of rails, end from cage. Guards ✓ Walk ✓ Collectors ✓ Trolley Wires ✓

GENERAL: Clean.

Crane inspection report—sent to repair department for information and guidance

overtime, the amount being 15 minutes each day. Cranes which are taken care of during regular working hours are those located on runways by themselves. In our foundries we devote the daily 15 minutes to cleaning cranes and in addition clean them thoroughly on Saturday afternoon.

The phrase, "What is everybody's business is nobody's business" is especially applicable to the inspection of buildings and grounds. Therefore, we delegate the responsibility to an individual. The inspector on this work covers a territory which embraces approximately 5,250,000 sq. ft. of manufacturing and office floor space in addition to 166 acres of ground. He pays particular attention to the condition of roofs, skylights, structures, sewers, floors, piping, bridges, tracks, yards, floor loading, and the like.

Incentive Wage

Our Time Study Department is making an effort to place all maintenance work on an incentive basis. Much good work has been done along this line, especially on new work. Where this wage payment plan can be applied, we advocate its use. Representative figures showing the savings made by wage incentive may be of interest:

Class of Work	Per Cent Saved
Concreting	20
Laboring	30
Carpentering	25
Roofing	30
Pipefitting	30
Structural Steel Working	35
Sheet Metal Working	30
Painting (Hand)	20
Painting (Spray)	40
Pipe Covering	25
Shop Wiring	40
Janitoring	45

These savings were accomplished by careful analysis and timing of the various operations. The time values set for performing work are controls in the hands of the supervisors, and also goals for the workmen. Application of time study brought out the fact that on a number of jobs fewer men could be used with greater efficiency per man, and that better planning of the work could be done. The men themselves now offer suggestions and they raise serious objections to anything which might cause a delay in the completion of a job. Where previously the men would make a job last until another one was given, they now come to their supervisors for their next job before the completion of the task upon which they are working.

A striking illustration of how savings can be effected in maintenance work by the use of an incentive wage payment plan is that of spray painting. Under the day work plan it was customary to have a group of 13 men using two tanks with four spray guns. While four men were using the guns the others were covering and uncovering the material on the floor, moving scaffolds, and furnishing the spray men with material. After the job was studied and a time value established, the group was reduced to 10 men, and three tanks with six guns instead of four guns were used. After the job had been in progress for some time, the group leader observed that he could do the job efficiently with one less. In this case not only did the company gain, but the men also had the advantage of higher earnings.

In view of these savings we are considering the problem of placing certain classes of repair work, such as electrical repairs, crane repairs, and the like, on an incentive basis. Due to the nature of the work and the difficulty in obtaining adequate data, we are making very slow progress in this direction. However, we believe that much can be accomplished in that field.

Schedules and Standards

The Works Engineering Department, in conjunction with the Inspection Department, has laid out a program

CONVEYOR INSPECTION REPORT NO. 31

Conveyor No. 23 Section K-12 Date 2-10-31 Inspected By G. Riling

Motor O.K.

Controller Motor drive chain is loose
Contacts burnt

Push Button Control O.K.

Signal Bell

Worm

Worm Gear

Bearings One bolt loose in drive shaft bearing

Shafts and Collars O.K.

Gears O.K.

Sprocket Wheels Set screw loose

Sprocket Chains O.K.

Rollers Bracket bent

Load Carriers O.K.

Chain Guides O.K.

Conveyor Frame Loose bolt in second hanger

Guards O.K.

General Clean

Conveyor inspection report. Mimeographed because quantity required is small

for the repair and painting of building structures. For instance, metal window frames, due to the kind of work carried on in a certain part of a building, will begin to deteriorate rapidly after a certain length of time if they are not protected by paint. Exposed metal structures, such as crane runways, smoke stacks, bridges, tanks, yard lighting systems, etc., also are placed on schedules.

Realizing that workmen will unconsciously reflect their personality in their workmanship, which naturally results in as many kinds of installations as there are men, the Works Engineering Department adopted a number of standards which are believed to be the best and latest practice. Obviously, with standard methods of construction and installation, the training of workmen in diagnosing and remedying troubles is more easily accomplished.

Equipment should be designed so that all parts are not only readily accessible for replacement but also for inspection. Gears on equipment purchased from various manufacturers are guarded either by cast-iron cases or sheet-metal guards, usually secured in place by bolts and nuts. When so constructed they may, in some cases, be a source of accidents. For instance, if the guard is so mounted that its removal requires numerous tools, the result is that either the guard is eventually thrown away or that no inspection or lubrication will be made of the parts which are inclosed by it. Guards should be so designed as to facilitate repairs and allow for ease of lubrication and proper inspection. This may be accomplished by the use of pins, hinges, sliding doors, or snaps.

It was previously mentioned that practically all of our installations are governed by state laws. On the original installation these laws are complied with, through information furnished by the works engineering departments. However, when repairs or replacements are made, the workman may deviate from these laws with the result that the state inspectors submit a report to the department at Harrisburg which compels us to rectify the violations. Our inspectors and foremen pay especial attention to this point, and we now have little trouble.

It is frankly admitted that our men are not perfect and do not see every detail which might cause an interruption in service, but by continually emphasizing its importance we are striving to reach that ideal whereby interruptions in production due to breakdowns will be reduced to the minimum. It is our firm belief that maintenance inspection is necessary; first, it accomplishes standard installations; second, it lowers costs of installations; third, it prevents the breaking down of equipment; fourth, it eliminates hazards; fifth, it promotes morale of employees; and sixth, it insures a better continuity of service. Any or all of these factors undoubtedly result in a reduction in the manufacturing cost of our products.

■ ■ ■

Organization and Operation of the Electrical Maintenance Department

SIDNEY WATKINS
Electrical Engineer
The Warner & Swasey Company
Cleveland, Ohio

OF GREAT importance in the maintenance of electrical equipment is the personnel of the electrical department. There was a time when the maintenance of electrical equipment could, with fair economy, be placed in the hands of the "jack-of-all-trades" who did the odd jobs around the plant. There were, probably, only a few motors, the factory was manufacturing for stock, and delays and breakdowns did not interfere with sales promises.

A parallel case was where the old family coachman became chauffeur when the family carriage was replaced by the automobile. Some of the old coachmen did very well with the automobile of that day, because breakdowns were the usual thing. But today, if a family were going to hire a chauffeur to drive their automobiles, they would hardly consider the coachman as sufficiently qualified.

There still are some industries that have the coachman idea; they place the maintenance of electrical equipment in the hands of millwrights or others who have very little knowledge of the electrical apparatus or training in the proper care of it.

The electrical maintenance department offers a field of opportunity to the technically trained man if he is given a chance to apply modern electrical equipment to the solution of some of the problems of industry. It is not a very tempting field if one finds that he is expected to do millwright work as well as electrical work. With the increasing adaptation by industry of what was formerly considered laboratory apparatus, it is important that we have men of the right calibre and training for installation and application.

Before the days of mass production the failure of an

individual piece of equipment was not serious, but today, with only a few hours between raw material and the finished product, it may easily mean holding up the main production. Therefore the most important duty of the electrical maintenance man is the prevention of breakdowns or failures of equipment. Doing so demands a higher standard of knowledge and training than is required to patch up or repair apparatus after it has failed.

Responsibility

Next in importance to the personnel in the department comes the question of department responsibility. The electrical department should be responsible to some high official in the organization. Electrical equipment, to give satisfactory service, must be properly installed and maintained. It is often difficult to obtain satisfactory consideration from minor officials or from men at the head of other departments. The usual response is, "Put it where the old equipment stood and let it run until it stops."

Sidney Watkins

Such conditions seldom are conducive to satisfactory service. If the electrical department is placed under the supervision of an official of high standing in the organization, we usually find a man who is familiar with the modern requirements for electrical equipment and who is ready to listen to suggestions for new applications. The electrical man, also, is placed in a position where he can insist that the equipment be provided with proper surroundings and that it be operated and serviced in such a manner as to guarantee satisfaction. If industry wishes to take the fullest advantage of the latest discoveries in electrical apparatus, a well-equipped electrical department with a properly trained personnel given authority corresponding to their responsibility will pay very good dividends.

Organization

If the industry is reasonably large, the electrical department should be divided into three groups: engineering, maintenance, and repairs.

The engineering group should keep all records, prepare all plans, and make specifications for the purchase of all new equipment.

A complete up-to-date plan of the electrical wiring system should be maintained, showing size and length of all circuits and the connected loads. Inspection schedules should be made by this group and inspectors' reports should be turned over to them.

Under the maintenance group include the inspectors, the operators of certain equipment, and the maintenance men who make such repairs and adjustments as can be made without stopping or replacing the machine. The repair group should take care of all rewinding of motors and coils and all major repairs requiring the removal of the equipment to the repair shop.

In small industries it is not always possible to maintain this division in groups because there is not sufficient work in each one, nor is there a sufficient number of men. However, this plan is followed by a number of industries with satisfactory results, and with slight changes to meet local conditions it can be applied advantageously to many others.

The equipment of the department is very important if the department is to function as it should in the organization. It is amazing what some men have accomplished with only a screw driver, a pair of pliers, and a hammer for tools.

A few years ago we considered ourselves lucky if we received an old, worn-out lathe or drill press. The balance of the equipment we were expected to make up ourselves. Modern equipment that has been designed especially for this kind of work is now obtainable and it costs less than the home-made articles. A few years ago an electrical measuring instrument was a luxury and a voltmeter and ammeter were considered all that an electrician would ever need. This was so in spite of the fact that we were handling an invisible, weightless, odorless conveyor of energy which was capable of performing useful work or of causing untold destruction.

A modern electrical department should have almost every kind of electrical instrument that is found in a college laboratory, but of course not so many. There is really very little that a man can find out about the condition of the insulation of a piece of electrical apparatus from a visual inspection. Of course if it is burned out, one does not need even a visual inspection, because he can tell by the odor. But if it is desired to prevent burn-outs and interruptions, which usually are costly to modern production, it is absolutely necessary to have suitable instruments. Prevention of burn-outs is one of the most important duties of the electrical department. That is why we recommend regular inspection and maintenance schedules. It is poor economy to follow after trouble and repair the damage, because it is seldom confined to the source but usually spreads to surrounding equipment.

The Location of the Electrical Department

The location of the electrical department seldom receives the consideration that it should have. Troubles come to the best organized and equipped industries, and to be able to repair the damage as quickly as possible is the usual objective of the maintenance men.

If the department is located in some dark corner at the extreme edge of the property it often requires more time to answer the trouble call and obtain repair parts than it does to locate the trouble and make the repairs. Therefore the department should be as centrally located as possible and should be large enough to accommodate the equipment and store repair parts, with ample space for storing material for new construction.

Operation of Department

A reliable signal system is necessary if trouble calls are to be taken care of promptly. Automatic call systems have many advantages over the telephone. Troubles have a peculiar habit of coming in bunches, and often it is necessary to reach an electrician after he has been sent out on one call to direct him to another one more important. The automatic call also makes it possible to have a general call for all maintenance men in case of a serious breakdown.

A regular inspection schedule for electrical equipment is a necessary feature of the maintenance department. Cranes and elevators should be inspected while in operation at least once each week and have a thorough inspec-

tion with the current off at least once a month. On important cranes and elevators with unusually hazardous duties, this should be changed to daily inspection in operation and complete inspection with machine shut down once each week.

A list of the points to be inspected should be furnished to the inspector and reports should be required from him. This arrangement will cause a more uniform inspection and will decrease the chance of some point being missed. It is the custom in some industries to shift the inspectors at regular intervals. This system has the advantage of keeping the men active because they know that another man shortly will be checking their work and it also makes a number of men familiar with the equipment in the whole plant. The gains by this system are obvious.

It is impossible to form a general schedule of inspection for motors and control equipment that will fit a very large number of plants. What might be considered a desirable schedule for a steel mill would be out of place in a machine tool factory. What might be satisfactory for a machine shop would be out of place in a clothing factory where most of the motors are of the fractional horsepower sizes. Then we find some plants with old equipment, with open-type, plain-bearing motors, while others in the same business have the fully inclosed motors with anti-friction bearings—serious differences.

Developing the thought that "the electrical maintenance engineer is the plant physician."

What we can say is that all motors and control equipment should be inspected at regular intervals and that the inspection should be such as to detect the usual causes of trouble.

The insulation resistance of every motor of any importance should be tested with a resistance-measuring instrument at least every six months and those in key positions should be tested each month.

Elevator controllers, reversing planer motor controllers, and other controls requiring frequent starting and reversing should have more frequent inspection and maintenance than those which are seldom stopped or reversed.

One of the greatest enemies of electrical apparatus is heat. It limits the output, ruins the insulations, increases the resistance, takes the temper out of spring contacts, unsolders connecting terminals, and melts protective devices.

There are two ways in which heat does its destructive work. The first and most spectacular way is when some line or piece of equipment is suddenly overloaded or short-circuited due to an accident. It is not difficult to locate this kind of trouble because it usually leaves a blazing trail. There is little in the way of prevention that an electrician can do other than provide suitable protective devices.

The second way in which heat gets in its destructive work may be likened to that of a thief in the night. The insulation of some electrical equipment becomes weakened by friction or vibration, metal dust, oil, or other cause. The heat developed by the current leaking through this weakened insulation causes the insulation to become weaker, which permits more current to pass, with the final result that the insulation breaks down and we have a ground or short circuit. This is the most common way in which burn-outs in electrical equipment occur. It is in preventing this kind of destruction that the well-equipped electrical department justifies the investment. A regular program of inspection and maintenance will detect the weakened condition of the insulation before it reaches the dangerous stage.

Maintenance of Transformers and Oil Switches

The transformer is one of the most important pieces of electrical equipment and it receives the least care. However, when it does burn out, the system it supplies is down until a new transformer is obtained.

A transformer should be inspected at least every six months. There are only a few points to cover. The level of the oil should be noted and its insulating qualities tested at least once each year. The temperature of the oil should be observed to see that the transformer is not overloaded. The bushings should be kept clean and be tested for insulating qualities at least once each year. Oil switches should be given a thorough inspection at least once every six months. The oil pan should be removed and the condition and level of the oil should be noted. The line-up of the contacts should be checked and the contacts cleaned free of burrs or scored surfaces. The bushings should be cleaned and inspected for breaks and be tested for insulating qualities. Relays should be cleaned and tested. Oil switches that are used in starting rotary converters and those that are operated at frequent intervals should have more frequent attention. Switchboards with open buss bars and knife switches and fuses should be kept free from dust by frequent blowing out with air. Spring contacts and cable terminal retaining nuts should be regularly inspected for heating due to poor contact. If the distribution circuits leading from the switchboard are tested with a Megger for insulation resistance to the ground, a check of the whole wiring system can be quickly made.

Distribution cabinets should be kept clean and free from moisture and oil. Switch and fuse spring contacts should be checked for proper tension and retaining nuts on cable terminals should be kept tight.

Select the Personnel

It is impossible to cover the whole field of activity of the electrical maintenance man in a paper of this nature and I realize that many important items have been omitted. Nothing has been said regarding the hazards of the profession, nor of the many modern safety appliances for the protection of men operating electrical equipment. It has been my experience that a large majority of the accidents resulting in personal injury have been due to persons attempting to do electrical work who have little or no knowledge of electricity or training in the proper methods of handling it. Of real importance, then, is the selection of personnel for the department.

If I were asked to give one rule that would apply to all industries, I would give this rule: "Do not permit anyone to do electrical work other than the men who have been trained for that job."

THE CONTROL OF NON-PRODUCTIVE COSTS

"This method detects unbalance the minute it occurs. It makes business administrators of departmental foremen and enables them to tell the money where to go, rather than to look sad because it went and they can't get it back."

HARRY W. BENTON

Plant Engineer
Pratt and Whitney Company
Hartford, Conn.

IN MY early industrial experience, even in plants of moderate size, information concerning costs seemed to be possessed exclusively by management. The average shop foreman or departmental supervisor was not trusted with such important items. He was not supposed to know even what his departmental supplies cost. His seemed to be merely the task of producing or supervising. In fact, I have known shops in which the departmental foremen did not know the rates paid to the employees under their direction.

The general superintendent was the man in possession of all data relative to cost, and he seemed specially instructed to guard them diligently. His was the task of converting cost data into terms of number of men required for productive and non-productive departments. His was the responsibility for economical and efficient shop management and supervision. Departmental foremen really were agents for carrying out the details which he decided were necessary.

The viewpoint of the leaders in industry has changed; there is a better understanding on the part of workmen with regard to the problems of management and there has developed a greater faith in the minds of management toward the loyalty of their men.

Industry has progressed in productive methods and cost reduction in productive departments. As we give recognition to industrial costs today, we are focusing our attention to the reduction of costs in strictly non-productive departments as the field offering the greatest opportunities for further economies in manufacture.

I was associated with a large manufacturing plant in which use was made of certain standing expense accounts. For instance, SJB meant "Standard job order on buildings" and we were free to do anything whatsoever that was required for the maintenance and upkeep of buildings, charging all time and material so used to SJB. Similarly, SJE was "Standing job order on equipment"; SJM "Standing job order on machinery"; SJP "Standing job order on power."

We were free to proceed almost without supervision to do anything we considered necessary in the operation and upkeep of equipment and buildings, charging the time and material to the standing job orders enumerated, merely adding the number of the department or building involved.

Each month the separate accounts were totaled by the cost office. If management decided that the expense was too great instructions were issued that next month certain account numbers must be watched carefully and the expenditures reduced. I cite this case for comparative purposes.

About six years ago it was my privilege to be an employee in a manufacturing plant employing in normal times about 2,100 to 2,300 employees. The manufacturing processes were entirely machine shop work; heat-treating; and small assembly. (Assembled units weighed not more than 200 lb. each and were produced in quantities up to 1,500 per 8-hr. day.)

The general manager of this plant developed an effec-

Actual figures of

BUDGET STANDARDS: True Pro-

1926	Millwright Division	Oil Separator Division	Woodmill Division	Electric Division
June 27	34.50	11.75		12.00
June 28	307.50	235.50	42.50	130.25
June 29	316.75	234.50	50.75	132.00
June 30	323.00	232.50	51.00	130.50
July 1	321.00	220.25	51.00	132.00
July 2	314.25	249.00	51.00	133.50
July 3	160.50	119.50	27.50	50.50

First day shown is Sunday;
Last day shown is Saturday;

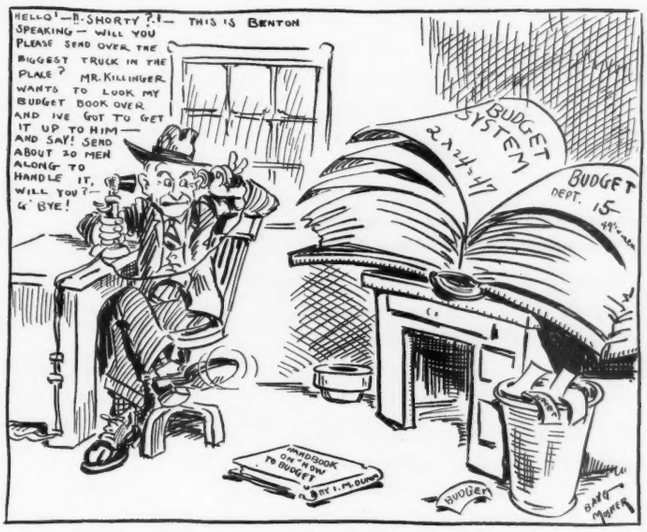
tive method of cost supervision which it is the purpose of this paper to present to you. I believe that it is the most satisfactory method of cost control in use today. The method is based on the "productive hour."

Further, it is the purpose of this paper to deal more particularly with the control of those elements of controllable cost that come within the province of the departmental foremen and the divisional supervisors.

Let us assume, for illustration, that we desire to establish this proposed system of control in an existing plant. We shall, first of all, have the Cost Department go into the records of the plant for a period of at least one year past (preferably two years) and make a survey of the labor hours. We shall have the Cost Office classify these labor hours into non-productive and productive hours, and further classify the productive departmental hours to show actual productive hours and non-productive hours by productive men. We have, therefore, three general classifications:

Strictly non-productive hours.

Strictly productive hours.


HELLO!—R. SHORTY ?!— THIS IS BENTON SPEAKING— WILL YOU PLEASE SEND OVER THE BIGGEST TRUCK IN THE PLACE ? MR. KILLINGER WANTS TO LOOK MY BUDGET BOOK OVER AND IVE GOT TO GET IT UP TO HIM— AND SAY! SEND ABOUT 20 MEN ALONG TO HANDLE IT, WILL YOU?— G' BYE!
BUDGET SYSTEM
BUDGET
DEPT. 15
HANDBOOK ON "HOW TO BUDGET"
BUDGET
PLANT MANAGER

No matter how large it is—it's still a budget!

Non-productive hours in productive departments by productive men. It is surprising when a survey of this kind is made to find just how large an amount of non-productive work, as expressed in terms of time, is performed by strictly productive men.

Assume, in our hypothetical plant, a strictly productive department with 70 men, all having rung in at 7 a. m. With the shop working on a 9-hr. schedule, there are apparently 630 productive hours. However, experience shows that during the day certain of these 70 productive men will have met with delay, such as waiting for stock, waiting for set-up men, waiting for power; and belt delay, electric power delay, and so on.

In each of these delay cases, some sort of special time ticket is made out, charging the time to a non-productive account number. The time so charged may amount to as much as 8 per cent of the total possible productive time in a well-organized plant. In excess of 8 per cent is quite common in plants not so well supervised.

Now for some figures from an actual plant. Distribution of labor hours in the Plant Engineer's department is shown by Table 1. The total hours of factory productive time are the hours that would have been worked by strictly productive employees, if none of them had charged any time to non-productive accounts. The difference between this item and the true productive hours represents the number of non-productive hours worked by strictly productive men, and this difference is charged as non-productive expense. Departmental hours, when compared with true productive hours, show a departmental per cent of 16.4 for the week, and from 13 to 24.4 daily.

Table 2 shows the total productive hours and total departmental hours for the month with a departmental performance of 15.9 per cent for that period.

Table 3 shows the budget standards for all departments (productive and non-productive) throughout the plant. Note that the amount of scrap allowed for productive departments is given in terms of dollars and cents for each 100 productive hours in each department.

TABLE 1—NON-PRODUCTIVE TIME ANALYSIS

departmental hours in Plant Engineer's Department, first year of this system of control.

ductive Hours = Total Productive Hours × 0.92. Non-Productive Hours = True Productive Hours × 17.3.

Outside Labor Division	Steam Fitters Division	Furnace Repair Division	Sheet Metal Division	Painting Division	Janitors Moppers Machine-Cleaners	Steam Power Plant	Dept. Super.	Total Dept'l Hours Non-Prod.	Total Hrs. Factory Productive	True Hours Productive	Dept'l Percents
	12.00					61.25		131.50			
128.00	85.50	31.50	106.50	17.00	187.50	94.00	33.50	1,399.25	10,922	10,079	13.8
128.50	83.50	25.50	102.75	17.00	184.75	106.00	33.50	1,415.50	10,023	9,191	15.4
121.50	85.50	27.50	108.00	17.00	162.00	98.50	33.50	1,390.50	9,301	8,629	16.1
128.00	75.00	25.50	115.00	17.00	181.50	107.00	33.50	1,406.75	9,695	9,004	15.7
128.50	83.50	25.50	112.00	17.00	184.00	106.00	33.50	1,437.75	9,229	8,551	16.8
80.00	42.00		48.00	5.00	101.50	60.00	20.50	715.00	3,117	2,930	24.4
								7,899.25		48,384	16.4

131.5 hr. of non-productive work performed in five departments; no productive work.
scattered productive work going on; non-productive work about half that of a week day.

TABLE 2—SUMMARY OF PLANT ENGINEER'S DEPARTMENT TIME CONSUMPTION FOR ONE MONTH

Departmental Non-Productive Hours	Purely Productive Hours
6,388.00	39,366
8,185.75	50,378
8,226.75	51,761
8,062.00	51,866
4,339.75	27,899
35,202.25	221,270

$$\frac{35,202.25}{221,270} = 15.9 \text{ per cent}$$

For the month the Plant Engineer's Department performed its services to productive departments with 15.9 hr. labor for each 100 hr. of productive time.

Budget standards allowed 17.3 hr., so it is seen that the department was performing very creditably, showing a saving of 1.4 hr. for each 100 hr. of productive time.

In arriving at this figure the different pieces being manufactured were weighed and their value per piece was totaled, to arrive at a value per pound for scrap. This value was placed on any scrap coming from productive departments, rather then to attempt the intricate method of valuing each piece coming to scrap according to its actual value which was dependent upon how far the piece had traveled through processing. This valued price per pound was found to work out very satisfactorily. Non-productive departments, obviously, did not have a scrap allowance.

It will be noted that 95.7 per cent of the budgeted time of Department 1 (a productive department) was productive; also that Department 1 was permitted to have strictly non-productive labor of 4.3 per cent of the department's total time. If, by careful management and supervision, the foreman of that department could keep his non-productive time below 4.3 per cent, he would be making a decided improvement in his departmental performance. So on down the entire line of productive departments. Ratios are given for the departments required to work at night so that the regular 8-hr. assembly schedule could be maintained.

Ratios of non-productive hours to total true productive hours for all non-productive departments are budgeted in Table 3. The ratio for the period covered by chart 1 is 17.3 per cent (Departments 15 and 16). According to Table 1 performance was 16.4 per cent for the week. It is apparent that the Plant Engineer's Department was performing favorably.

In applying these ratios to the daily performance of the shop, there was a definite ruling that all labor which entered into and became a part of the product as sold was productive time. All other time, including the time of inspection, was non-productive. When inspection is classified as a non-productive burden on the productive department, the better work produced by the department will reduce the amount of inspection required and, therefore, reduce operating costs.

Each morning, commencing at about 7:15, all time clerks were required to count the cards rung in and report the number to the chief time clerk, who would multiply the number of productive men's cards by the number of hours in the normal day's work and this result by the factor 0.92 to obtain "true" production hours, and post the figure on the bulletin boards throughout the plant before 9 o'clock. For example, the figure obtained by multiplying cards by hours for Monday, June 28 (Table 1) was 10,922. $10,922 \times 0.92 = 10,048$, the figure posted on the bulletin board. Each non-productive departmental foreman would multiply this number by the ratio given for his department to arrive at the number of hours permitted for that day. That number of hours, divided by the hours per day, would give the foreman the number of men he should have. By asking his

TABLE 3—BUDGET STANDARDS

Productive Departments
Labor

Dept. No.	Supplies per Prod. Hr.	Scrap per 100 Prcd. Hrs.	Ratio Pure Prod. Hrs. to Total Dept. Hrs.	Ratio Non-Prcd. Hrs. to Total Dept. Hrs.
	Days			
	$	$	%	%
2	.432		95.7	4.3
5	.18	10.88	72.	28.
6	.145	2.85	89.1	10.9
10A	.95		86.5	13.5
10B	.692	8.32	96.8	3.2
11	.171	4.60	91.5	8.5
12	.242	7.47	78.	22.
14	.425	11.84	79.	21.
19	.157	3.37	87.7	12.3
20	.054	.27	94.1	5.9
21	.093	4.77	73.2	26.8
24	.099	4.91	79.5	20.5
26	.116	6.08	89.4	10.6
27	.145	4.68	82.7	17.3
34	.028		2.54	
36	.0023		2.64	
38	.0005	1.39	1.64	
55	.081	5.75		
57	.321		44.2	55.8
58	.992		51.8	48.2
59	.605	19.78	65.7	34.3
Average for Prod. Depts.	$.235	$7.006		

NOTES

The budget allows 1.33 hr. of labor by Non-Productive Dept. 3 for Productive Dept. 5 for each 100 hr. of True Productive time in Dept. 5.

The budget allows 1.14 hr. of labor by Non-Productive Dept. 3 for each 100 hr. of labor in Non-Productive Dept. 3.

Note that Dept. 3 had 84 men. 84×8.5 hr. per day = 714 hr. departmental time. $\frac{714 \times 1.14}{100} = 8.1396$, say 8 hr. This shows that Dept. 3 was permitted to devote 8 hours that day to the repair of its own departmental equipment.

The table indicates that Depts. 3, 18 and 22 devote their time to all departments. The figures in columns marked "Production Departments" are the budget standards of time allowed to the Productive Departments opposite the figures given. The same is true of budget standards for Non-Productive Departments.

time clerk how many men were rung in in his department, or by counting his own clock cards, he would know in less than two minutes whether or not his department was over-manned, even with, or below the ratio.

By the same method, having calculated the number of hours in his department for the day, one simple calculation, based on the amount of money allotted to his department for each departmental hour for supplies, gave him the total amount of money he was permitted to spend for the day for supplies.

Thus each foreman knows before 9 o'clock each morning exactly how his department is performing. If it is out of step, he immediately looks for the cause and begins correction. In this manner, the shop is kept performing in balance; it is not necessary to wait for the cost office to discover something wrong at the end of the month, after the expenditures have been made.

This method detects unbalance the minute it occurs. It makes business administrators of departmental foremen and enables them to tell the money where to go, rather than to look sad because it went and they can't get it back.

It also provides a departmental daily performance sheet which consists chiefly of the departmental ratios shown in Table 3. This sheet is printed in black ink and in the blank spaces next to the standard ratios the chief time clerk fills in the daily performance in black ink. If performance is not in excess of the standards the entry is made in black. If it is in excess red ink is used.

TABLE 3—BUDGET STANDARDS

Nights						Non-Productive Depts.					
						Repairs by Dept. No. 3.		Repairs by Dept. No. 18.		Repairs by Dept. No. 22.	
Ratio Pure Prod. Hrs. to Total Dept. Hrs.	Ratio Non-Prod. Hrs. to Total Dept. Hrs.	Dept. No.	Supplies per Dept. Hr.	Ratio Dept. Hrs. to Total Pure Prod. Hrs.		Hrs. per 100 Dept. Prod. Hrs.	Hrs. per 100 Dept. Total Hrs.	Hrs. per 100 Dept. Prod. Hrs.	Hrs. per 100 Dept. Total Hrs.	Hrs. per 100 Dept. Prod. Hrs.	Hrs. per 100 Dept. Total Hrs.
%	%		$	*	%	Prod. Depts.	Non-Prod. Depts.	Prod. Depts.	Non-Prod. Depts.	Prod. Depts.	Non-Prod. Depts.
		1	.059	12	1.06						
73.4	26.6	3	.018	84	7.42	1.33	1.14	11.36	.16	1.45	.35
79.5	20.5	4	.0012	18	1.49	1.74		2.28		3.61	
		8	.019	24	2.19	.14	.019	.18	.22	.066	
		9	.0008	60	5.19	.038	.34	.21		.019	.019
88.	12.	13	.0038	24	1.91	.52	.24	1.39	.005	.65	.019
76.8	23.2	15	.017			4.97	.008	6.41	.07	16.62	.019
77.6	22.4	16	.23	205	17.3	1.53	.009	2.00	.15	4.07	.028
83.	17.	17	.19	2	.14	2.30		2.14		4.48	
		18	.024	60	5.01	.076	.057	.028	.26	.028	.009
		22	.084	54	4.64	1.12	.21	2.81	.26	2.31	2.26
81.2	18.8	29	.0015	108	8.74	4.76	1.71	2.74	.05	3.61	.009
94.9	5.1	35	.681	36	2.97	1.97		2.35		1.36	
83.	17.	37	.44	10	.9	4.07	.27	3.50	.29	9.65	.32
		39	.019	56	4.71	.20		.56		.35	
		42	.022	46	3.79	.076	.057		.123		.047
		43	.0076	24	2.11	.82	.028	.12	.475		.028
		44	.0019	32	2.64	2.85		1.39		1.77	
		45	.0006	6	.55		.41				.019
		65	.013	16	1.9	.019		2.65			
		80		14	1.34	.066		15.27		.028	
		81		6	.58						
		82		4	.34						
		83		5	.46						
		84		13	1.12						
		85		46	4.92						
		86		16	1.36						
		87		5	.45		.27		.50		.57
		88		8	.68						
		89		6	.49						
		90		5	.465						
		91		1	.082						
		92		42	3.65						
		93		16	1.25						
		94		8	.71						
		95		3	.24						
		96		13	1.19						
		97		4	.36						
		98		6	.47						
Average for Non-Productive Depts.			.086	1098							

*Figures in this column are approx. number of men in non-productive departments.

Total number of Productive men 1285
Total number of Non-productive men 1098.

TABLE 4

	Actual True Prod. Hours in Factory	Actual Non-Prod. Hours Plant Eng'r's Dept.	Ratio of Column No. 2 to Column No. 1	Estimated Non-Prod. Hours at 14.8%	Estimated Saving in Non-Prod. Time
JAN.	275377	46532	16.9%	40756	5776
FEB.	232770	38680	16.7	34450	4230
MAR.	223067	41584	18.6	33014	8570
APR.	220891	34926	15.9	32692	2234
MAY	203538	29958	14.8	O. K.	....
JUNE	203864	31761	15.6	30172	1589
JULY	184260	30801	16.7	27270	3531
AUG.	163330	21397	13.1	24173	....
SEPT.	165841	28604	17.2	24644	3960
OCT.	153183	28205	18.4	22671	5534
NOV.	110780	21062	19.0	16395	4667
DEC.	116323	23021	19.8	17216	5805
				Estimated total saving....	45896

Estimated saving @ 60c per hour:
45896 × $0.60 = $27,537.60

To this amount add cost of supplies that would not have been used.

NOTE: August was vacation month, so that regular working schedule was out of balance. Non-productive departments particularly were all practically shut down for one entire week. This accounts for very low ratio of Plant Engineer's Dept.

The sheet, when completed, is delivered to the Works Manager and a duplicate is given to the General Manager each morning not later than 9 o'clock. At that time, of course the sheet really is an estimated performance for the day. Two days later, when the actual figures are compiled the manager receives the estimated performance for the current day and the actual performance for two days previous.

Since each foreman knows, by 9 o'clock each morning, what his departmental performance is likely to be for the day, and since he knows that the figures are also presented to the General Manager and the Works Manager, there are no misunderstandings. The foreman knows that the management knows just what is happening. If there exist, for the time being, conditions that are beyond the control of the foreman, he has no fear in taking his problem to the management and laying the cards on the table.

One of the most important results of this method of supervision is the satisfaction that comes personally to every departmental foreman. There is also his confidence that he will not be humiliated for departmental failures at the regular foremen's meetings. The meetings become round-table discussions of general shop procedure. The spirit and ability of the men simply work wonders beyond the expectation of the management in reducing non-productive costs.

After one year's experience in the plant to which I am referring, the management decided to revise the ratios where the year's experience had shown that the original ratios were in error. Some departments were able to function below the budget ratios, others were unable to meet them. These conditions were corrected for the second year and it was also decided that at the end of each three months of the second year the ratios were to be revised downward in all departments where reductions had been accomplished constantly for the three months' period.

After the second year's experience, the ratios had been so revised that it seemed as though further reduction costs would be a difficult matter. The management, therefore, established a bonus system of payment in cash to the foreman of any department who reduced his departmental costs below the standards as given. Payment was to be 10 per cent of the actual savings, for the period of three months, except that the total amount paid out at any one time would not be in excess of $50. It is interesting to note that the leader of one of the divisions in the Plant Engineer's Department was paid $50 (the maximum amount of bonus) five times during the period of two years.

In my opinion this method of paying bonuses to non-productive departments is practicable. It has long been recognized as a comparatively easy matter to establish premium, or piece work, or prizes, for productive departmental employees, but to determine similar payments for non-productive employees has been a difficult problem. This method incorporates the co-ordinated efforts of every man in the group and puts the responsibility for sustaining that effort where it rightly belongs, the supervisory department.

In order to indicate the advantages of the method described, I present Table 4 which consists of figures of performance in an actual manufacturing plant as they have come to my attention recently.

■

Waste Elimination Award

AGAIN an award of $50 for the best suggestion on any phase of waste elimination in industry will be offered by the National Industrial Exposition.

The suggestion should be explained in a letter (accompanied by a sketch if necessary) not exceeding 300 words showing how the idea can be carried out and the savings effected. Letters will be received by the National Industrial Equipment Exposition, 308 West Washington St., Chicago, Ill., up to midnight, May 30, 1931.

Descriptions of suggestion systems and "elimination of waste" campaigns will not be considered by the committee, as the award this year will be presented for a suggestion showing concrete savings, with information that can be used to advantage by other concerns.

The Award Committee will consist of Geo. T. Trundell, president of the Trundell Engineering Company, Cleveland, Ohio; Oscar Grothe, vice-president of the White Sewing Machine Company, Cleveland, Ohio; Prof. John Younger, Ohio State University, Columbus, Ohio.

Homer J. Nelson, of the industrial economy department, Eastman Kodak Company, Kodak Park, Rochester, N. Y., was the winner of the prize offered last year.

Mr. Nelson's plan aimed at the elimination of waste at its source. It was designed to assist department heads in setting up an inspection system within their departments, together with the necessary rules and instructions for its proper operation.

It was also recommended that all waste receptacles be painted with appropriate signs as a propaganda campaign against waste.

Maintenance Factors That Control the Effectiveness of a Lighting System

True maintenance includes the adoption of ways and means for keeping the lighting of buildings up-to-date.

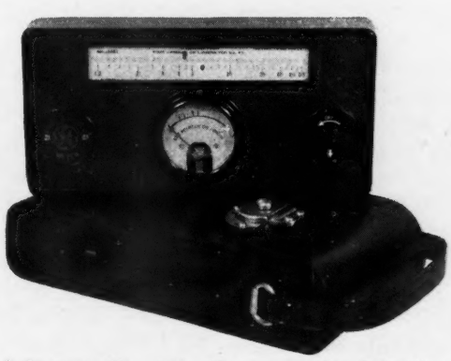
WALTER STURROCK

Illuminating Engineer
Nela Park Engineering Department
General Electric Company
Cleveland, Ohio

MAINTAINING the lighting system implies procedure that will cause normal, satisfactory operation. In a broader sense, however, maintenance includes changes or extensions in the lighting system, some of which are necessary because of rearrangements of partitions or changes in work spaces, and others because the lighting system has become unsatisfactory due to its inadequacy.

In some buildings the most difficult problem the maintenance engineer confronts is that of supplying the increasing demand for higher levels of illumination. If the wiring is inadequate as initially installed it is often impossible to comply with these demands for more light because complete rewiring may be so costly that the maintenance budget cannot handle it. The building then becomes obsolete in one of its essentials. Lighting maintenance problems may be fairly simple or extremely difficult, depending upon the selection of the equipment for the initial installation, including wire, conduit, panelboards, switches, location of outlets, and lighting units.

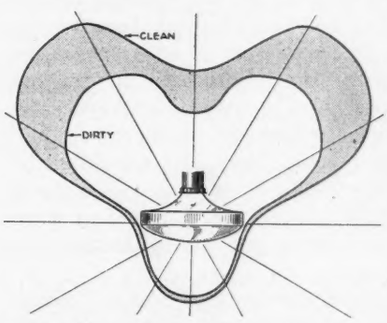
I have divided my discussion into two parts with the thought of presenting, first, some of the important factors relating to the maintenance of a lighting system, and second, factors controlling the initial installation of an interior lighting system which will facilitate its maintenance throughout the life of the building.



A foot-candle meter (for measuring intensity of illumination).

PART I

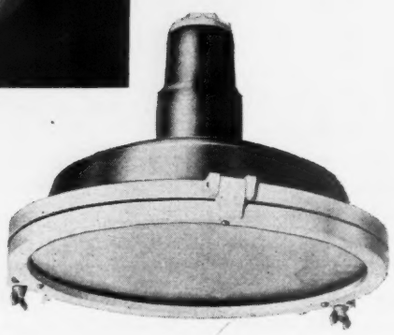
When a lighting system is installed which is capable of delivering an average of 10 or 15 foot-candles of illumination under service conditions, it is false economy to let it depreciate to such an extent that this average level is not maintained. Lighting units of all types accumulate dust and dirt to some extent regardless of their design. Indirect and semi-indirect lighting units are in general the worst dust collectors, and even those which are totally inclosed get dirty. An accompanying diagram shows the "before and after" light output of a semi-indirect inclosed unit which had not been cleaned for several weeks; one-third of the light was absorbed by the dust and dirt which had collected during that time.



Before-and-after light output of a semi-indirect, inclosed unit, allowed to accumulate dirt for several weeks. One-third of the light was lost.

For an inclosed type of unit, however, the dirt collects on the outside rather than on the inside. This is an advantage when cleaning.

In one of our Cleveland industrial plants, in which there is perhaps no more than the average collection of dust and dirt, the lighting units are cleaned at intervals of 10 days. The cleaning plan found satisfactory is to wipe the units with a dry cloth on the first and second cleanings and on the third remove the globes and give them a thorough washing. Cleaning the 770 Glassteel Diffuser units requires the services of one man full time. The accumulation of dust never reaches the point of absorbing 25 to 50 per cent of the light output. The management of this plant feels that the investment in his lighting main-



Typical dust-tight and vapor-proof lighting units.

tenance department unquestionably has been profitable.

The best all-round method for cleaning lighting units is to use good soap and water. Common cleaning agents, such as Bon Ami and Old Dutch Cleanser, are effective for removing oily dirt and grease. If, however, the lighting units are covered with paint, varnish, or tar, then an organic solvent such as acetone or benzol should be used. In most of our interiors dry dust and smoke are responsible for dirty lighting units. Under this condition the units can be fairly well cleaned by wiping with a damp cloth, but they should be washed every second or third cleaning period, a period being not more than three or four weeks.

A recommended cleaning schedule is shown in Table 1. This table indicates that there is no one cleaning schedule that will fit all conditions. Hence it is desirable to have some method of making an overall check to determine whether or not a lighting system is operating efficiently. Such a check can be obtained simply and inexpensively by means of a foot-candle meter, illustrated, with which the level of illumination can be measured at the point of work.

Special dust-tight lighting units have been developed to provide safe lighting in atmospheres containing explosive or flammable dusts, and for use in extremely dirty locations. In these units the breathing action, that is, the contraction and expansion of the air inside when the lamps are turned on and off, is minimized and consequently they may be cleaned simply by wiping or washing the outside surface. A typical dust-tight lighting unit is illustrated.

Some of these dust-tight units are made vapor-proof, especially for use in refineries, acid plants, and other places where there are volatile gases in the atmosphere, or acids present which would in a very short time destroy the lamp bases, sockets, wire, and any other exposed copper or brass parts.

The work involved in the cleaning of lighting units depends not only upon the design but also upon the method of supporting it. This is particularly true for all types which must be removed from the holder for cleaning or which are difficult to reach because of their location. In purchasing and installing lighting equipment, attention should be given to the ease with which the units may be removed for cleaning. For example, the cleaning of most industrial units would be much easier if the reflectors were suspended from hooks and equipped with separable plugs for the electrical connections. An accompanying line drawing shows two forms of hook suspension; other forms sometimes will be found preferable, depending upon the type of ceiling construction and the type of lighting unit used. These disconnecting devices make it unnecessary for the maintenance man to carry his cleaning equipment up the step ladder. In fact, by having an extra lighting unit available, it is possible to carry the clean unit up the ladder and put it in place of the dirty one which is brought down to the floor for cleaning. This one becomes the clean unit for the next outlet, and so on. By use of this scheme one industrial plant reduced the cleaning cost per unit from 14 to 3c each.

For lighting units which are difficult to reach, or hazardous to maintain because of their location, some form of disconnecting hanger with lowering cables is recommended. The replacement of burned-out lamps usually is a job for the plant electrician rather than the cleaning man. And it rightly should be, because he is the one who will keep the proper size of lamp in each socket and also see that burned-out lamps are replaced at the earliest possible time. If the wrong size of lamp is placed in many of the units in use, it may make a considerable change in the light distribution characteristics as well as affect the efficiency of the unit. Also, under this condition, the quality of the light produced may be changed so that a normally satisfactory system is turned into an unsatisfactory one of glaring light sources. Some industrial plants have found it desirable to stencil on the outside of each reflector the proper size of lamp to be used in it. Also, to avoid the inconvenience of stocking many sizes, and to minimize the possibility of mistakes when installing them, some thought should be given, when planning a lighting system, to the use of only one lamp size throughout. Although this cannot always be done, it is

TABLE 1—RECOMMENDED CLEANING SCHEDULE

Type of Lighting Unit	Character of Location	Interval in Days Between Washings*
Direct Units, Inclosing Globes, and Closed Semi-Indirect Units	Very Dirty	7
	Dirty	15
	Average	30
	Clean	60
Open-Top Semi-Indirect and Indirect Units	Average	15
	Clean	30

*In locations where the lighting units accumulate nothing but dry dust or smoke, satisfactory results are obtained by washing the units on one cleaning period and merely wiping them with a damp cloth on the next cleaning period.

compatible with good engineering and feasible in many cases.

The average life of Mazda lamps is 1,000 hours when burned at the voltage indicated on the lamp bulb. This means that out of 100 lamps a few will be expected to burn out prior to the average life and a similar number will live longer than 1,000 hours. Table 2 shows a typical mortality rate for Mazda lamps.

It is thought by some people that the life of a lamp is seriously shortened on account of temperature rise when the lamp is placed in an inclosing globe with no ventilation. Careful tests, however, have proved that this is not true. In most instances ventilation by means of a hole in the bottom of the unit has been found to lower slightly the temperature of the lamp bulb, but this effect is negligible compared to the resulting higher temperature at the lamp base, socket, and wiring where heat is much more likely to cause trouble. Furthermore, ventilation tends to increase the amount of dust and dirt collecting on the inside of the globe. Hence properly designed inclosing units are not ventilated but are made with a radiating surface large enough to dissipate the heat of the lamp at a rate that does not allow an abnormal temperature rise.

TABLE 2—TYPICAL MORTALITY RATE OF MAZDA LAMPS

Hours Burned.....	0	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000
No. of Lamps Remaining	100	100	99	92	72	46	24	11	5	1	0

There are, of course, some conditions of shock and excessive vibration in industrial plants which greatly reduce lamp life. They can be greatly improved by the use of shock- and vibration-absorbing hangers and sockets. Trouble of this nature is most likely to be found among the lamps of lower wattage used for local lighting. Often the trouble can be eliminated by installing a good overhead lighting system using lamps of higher wattage, which has the advantage of eliminating broken lamp filaments and reducing bulb breakage.

There are artificial lighting systems employing skylights, coves, and white-plastered domes, which introduce other surfaces to be kept clean. Overhead skylights are rapid collectors of dust and dirt and must be cleaned periodically if artificial lighting equipment is to be employed above them. In many buildings these skylights were installed to permit natural daylight to be used and later found to be of little value because adjacent buildings had been erected. Where such conditions exist it is possible to house the artificial lighting equipment in dust-tight boxes, such as illustrated, fitted to the upper side of the ceiling skylight.

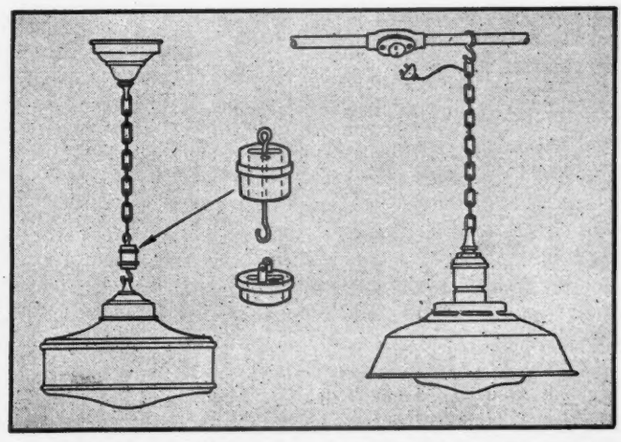
For cove lighting and other indirect systems, the ceiling is directly responsible for reflecting and diffusing the light to the work; it should be maintained with reflection factor of 70 per cent or more. White plaster or good white paint will reflect 80 per cent or more of the light striking it. Light cream and ivory paints have a reflection factor of 70 per cent or more. The side walls for most general interiors are considered quite satisfactory if they have a reflection factor of 40 to 50 per cent, which can be obtained from a buff or tan finish. The reflection factor of the ceiling as well as of the walls is not only important for indirect lighting systems but also for direct lighting, because it increases the amount of light available on the work surfaces. Table 3 shows how the interior finish of a room affects the foot-candles of illumination.

PART II

Of the many problems encountered in maintaining a lighting system the most difficult one to solve is that of making provision for increasing demands on the lighting circuits. The illumination in commercial and industrial interiors 15 years ago was considered fairly good if it averaged 5 or 6 foot-candles; this required an electrical provision of about 1 watt for each square foot of floor space. Seven or eight years ago it was found that the average illumination in the better lighted interiors had increased to 10 or 12 foot-candles. At least 50 per cent of this increase was obtained by a substantial improvement in the efficiency of the lamps employed for general lighting. Today 15 to 18 foot-candles of illumination are being demanded for ordinary work requiring some visual perception. These rapidly increasing demands on our wiring circuits have resulted in overloading the plant electrical distribution system in nearly all of the large buildings which are more than 3 or 4 years old. The overloaded circuits may be perfectly safe so far as any fire hazard is concerned, but they are economically poor and extremely wasteful because of the loss of electrical energy which would otherwise be utilized in producing light.

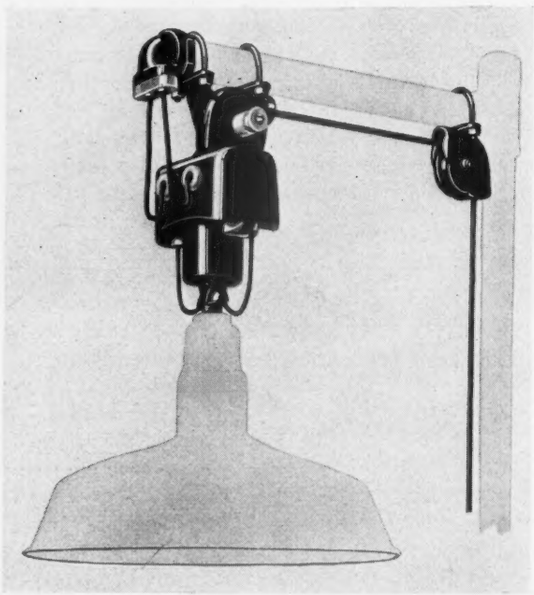
A recent voltage survey in a large store showed an average drop of 5.7 volts in its lighting circuits. On the shorter circuits the drop was found to be as low as 1.8 while on the longer circuits it ran as high as 8 volts. A similar survey in an office building showed an average drop of 8.3 volts in its branch circuits. In this building the shorter circuits showed losses as low as 1 volt, but as high as 11 on the longer circuits. These two buildings are typical of many others which cannot be rewired without a rather excessive cost.

On first consideration one might think that a few volts lost in a lighting circuit would result merely in the loss of a few light units from the lamp because of its undervoltage burning. This undervoltage burning is, however,



Two forms of hook suspension that facilitate cleaning.

more serious because the light output of the lamps is reduced approximately three times as fast as the voltage. To illustrate more definitely just what this means under actual conditions, suppose we have a branch circuit 75 ft. long of No. 14 wire which was installed to illuminate a given area with 6 100-watt, 115-volt lamps. This same circuit, or its equivalent, is today in many interiors equipped with 6 300-watt lamps. With 115 volts at the panelboard and No. 14 wire, the 600-watt original load at an average distance of 75 ft. caused a drop of approximately 2 volts which was considered the maximum allowable for economic operation. With lamps burning 2 volts under their rated voltage the light output was 94 per cent of normal. Today the use of 6 300-watt lamps on this circuit causes nearly 6 volts drop which results in only 84 per cent light output. On the other hand, if the original wiring system had been No. 10 wire, 98 per cent of normal light output would have been obtained from the 100-watt lamps, and today 93 per cent output would be obtained from 300-watt lamps. Based on 1,500 hours burning per year, and 3c per kilowatt hour for energy, Table 4 shows comparative results of using No. 14 wire and No. 10 wire on a 75-ft. branch circuit with the 6 outlets.



Disconnecting hanger with lowering cables, especially advantageous for use in connections difficult to reach or hazardous to maintain because of location.

With 100-watt lamps on this branch circuit, No. 10 wire with its lower voltage drop produces 4.3 per cent additional light from the lamp as compared with the amount of light obtained when using No. 14 wire. This is worth $1.23 when compared to the total cost. The additional annual cost of current and lamp renewals when the large size of wire is used amounts to $0.48; the net gain per year is $1.23 minus $0.48, or $0.75. The use of No. 10 wire in a 75-ft. branch circuit will have an installation cost of $5 or $6 more than No. 14 wire so that the annual return of $0.75 on this investment cannot be entirely overlooked. Of more importance, however, is the fact that when larger lamps are used on this same circuit the economic advantage of the larger wire size is more obvious. For example, with 300-watt lamps on the circuit, the additional investment of $5 to $6 for No. 10 wire means a net gain of $5.10 worth of light over that obtained with the No. 14 wire. This analysis is presented to emphasize the fact that the size of wires installed for a lighting system is an economic problem and not simply one of complying with a safety code. The first requirement for a wiring system is, of course, to furnish adequate capacity for at least the demands that exist at the present time.

It is a well-known fact that of two electrical specifications prepared for the same job, the one which simply complies with the National Electric Code requirements can be installed at a considerably lower cost than the one specifying the proper economic size of wire. But after the system involving lower initial cost is put into service the actual value of the light lost due to undervoltage conditions would, in 1½ years operation, equal the additional cost of having a carefully designed wiring system installed. The same line of reasoning can be applied to a lighting system which was designed seven or eight years ago for 150 watts per outlet with no extra capacity but which is using today 200 to 300 watts per outlet.

The National Electric Code regulations and the local municipal ordinances are intended to insure protection from fire hazard and do not necessarily give the proper size of wire for good practice. Furthermore, they do not in any way provide for future demands on the lighting circuit, and to take them as a guide for adequacy when installing a wiring system is often a costly procedure. There has been made available a specification of adequate wiring for commercial and public buildings which is most highly recommended for use by maintenance engineers and others who have either new or remodeling work to do. The specification of adequate wiring referred to was prepared by the National Electric Light Association in co-operation with other branches of the electrical industry and the following paragraphs are abstracted from it.*

TABLE 3—HOW THE INTERIOR FINISH AFFECTS THE FOOT-CANDLES

Ceiling Finish	Very Light	Fairly Light	Fairly Dark
Wall Finish	Fairly Light	Fairly Dark	Very Dark
RLM Dome	15.0	14.1	13.4
White Inclosing Globe	15.0	11.9	9.5
Semi-Indirect	15.0	10.4	6.8
Indirect	15.0	9.5	5.0

SPECIFICATION OF ADEQUATE WIRING FOR COMMERCIAL AND PUBLIC STRUCTURES

This specification is in conformity with the regulation of the National Electrical Code as regards current-carrying capacity and, in addition, makes reasonable provision for economical distribution of energy and the probable lighting requirements

* Complete copies available from National Electric Light Association, 420 Lexington Ave., New York, N. Y.

TABLE 4

Lamp Size Watts	No. 14 Wire	No. 10 Wire	Light	Annual Increases	Value
100 Volts	113.0	114.2			
Light Output	94%	98%	4.3%		$1.23
Current	$26.73	$26.90		$0.17	
Lamp Renewals	$1.87	$2.18		$0.31	
					$0.48
Cost	$28.60	$29.08		Net Gain	$0.75
300 Volts	109.2	112.7			
Light Output	84%	93%	10.7%		$8.86
Current	$78.65	$80.05		$1.40	
Lamp Renewals	$4.21	$6.57		$2.36	
					$3.76
Cost	$82.86	$86.62		Net Gain	$5.10

of the near future. It applies only to installations for connection to 115- or 115-230 volt distribution systems and does not apply to wiring for the supply of energy to power equipment. It is also based upon 15-amp. fusing of branch circuits.

Branch Circuits. Except as specified below there shall be one branch circuit for the general lighting for each 400 sq. ft. or less of working space or rentable area, and one branch circuit for general lighting for each 800 sq. ft. of hallways or passageway or other non-rentable or non-productive areas. (Exceptions—drafting and art rooms, 200 sq. ft.; auditoriums, school corridors, and hospital wards, 600 sq. ft.)

Based on the wattage of outlets specified on the lighting plans branch circuits shall be so arranged that the initial load on any circuit shall not exceed 1,000 watts except in the case of a single lamp of larger size.

The smallest size of wire that should be used in branch circuits is No. 12 gage, and for runs from a panelboard to the first outlet of from 50 ft. to 100 ft. No. 10 gage wire is the smallest that should be used with No. 12 between outlets. Runs exceeding 100 ft. from the panelboard to the first outlet should be avoided wherever praticable by relocation or addition of panelboards. Where such runs cannot be avoided, the lamp load should be limited to 600 watts and the area per circuit reduced by 40 per cent of that specified in the first paragraph.

Convenience outlets should be placed on a circuit separate from that supplying the general lighting. Not more than 10 convenience outlets shall be placed in one circuit and in barber shops, dentists' and doctors' offices, beauty parlors and similar places not more than two per circuit. For runs from the panelboard to the first outlet under 100 ft. wire not smaller than No. 12 should be used and not smaller than No. 10 where the runs must be longer.

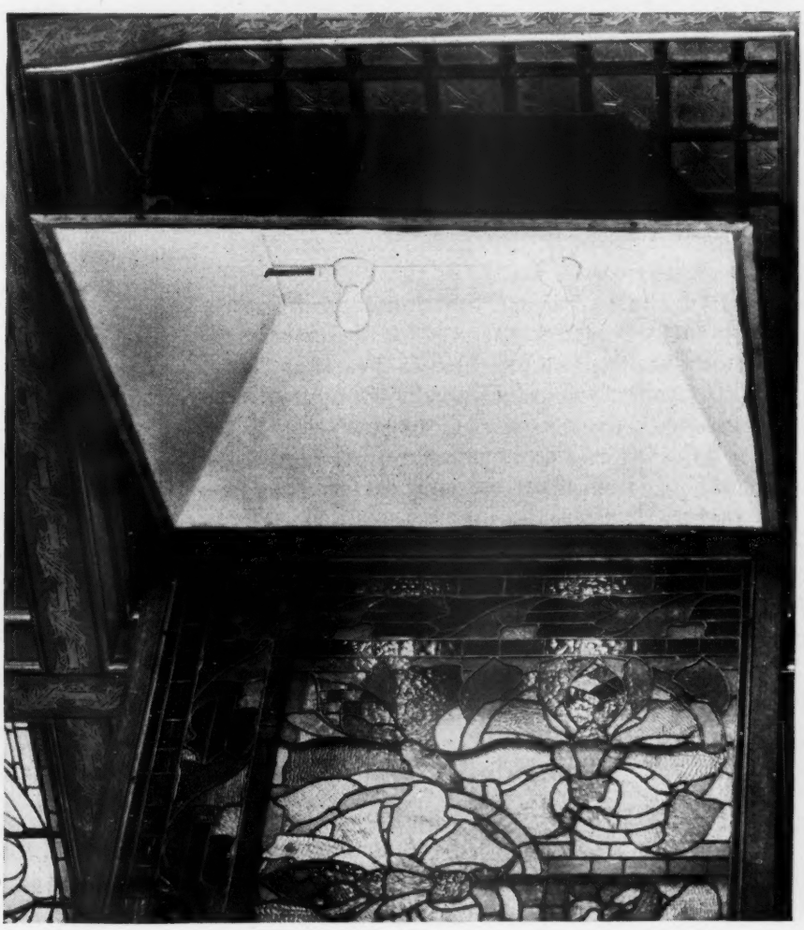
Panelboards. Panelboards shall contain a minimum of one spare circuit position for each five circuits in service or fraction thereof. It is recommended, but not required, that each circuit on panelboards be supplied with a switch in addition to the fuses, or with a circuit breaker, except that individual circuit switches or circuit breakers are not needed for circuits supplying show windows and signs controlled by time switches.

Feeders. The service and feeders shall be of such size that the total voltage drop from the service entrance to the panelboard will not exceed two per cent with a load equal to a total capacity as computed from the following: 7½ amp., 115 volts shall be supplied for every 15-amp. branch circuit position provided for on the panelboard or panelboards which they feed, except for buildings in which the floor area exceeds 10,000 sq. ft., in which case the standard demand factors of the 1930 National Electrical Code, Section 613, may be applied.

Conduits and ducts for inclosing service and feeders shall be of sufficient size to permit replacing the original service and feeders with wires two standard gage sizes larger or 50 per cent greater in capacity. Where conduits or ducts are not used, the original installation should have this excess capacity.

A similar specification for wiring for industrial buildings is being prepared.

Does the maintenance of a lighting system simply mean keeping the lighting units and all the reflecting surfaces clean and in keeping burned-out lamps replaced with new ones? No, it also includes the adoption of ways and means for keeping a building up-to-date with artificial lighting, and an acknowledgement of the fact that our present day levels of interior illumination are much below those we may be using a few years hence. Many maintenance engineers recognize this situation and in their relighting work are making provision for the use of 50 to 100 per cent additional capacity.



Dust-tight box, containing lighting equipment, for attachment to the upper side of a ceiling skylight under certain conditions.

MAINTENANCE ENGINEERING

L. C. MORROW, Editor

APRIL, 1931

Our Change of Name

WITH this issue *Maintenance Engineering* becomes the name of this publication. The purpose of the change in name is to express correctly the editorial objective, which is to serve the man responsible for the functions of maintenance in industrial plants. Since its founding, in 1882, as *Review of the Telephone and Telegraph,* this publication has consistently formulated and discussed the problems involved in maintaining uninterrupted production.

Not always did the function of maintenance have the standing that it enjoys today. For many years it was thought of as repair only. Today industry considers repair as only a minor phase of maintenance. The function of maintenance engineering is recognized as involving the selection and installation of much of the mechanical and electrical equipment for industrial plants, the systematic inspection and servicing of all equipment to prevent breakdown, the inspection and care of buildings, responsibility for the arteries of communication, lighting and protective systems, and so on.

This new recognition, constantly encouraged by this publication, enhanced rather than diminished by the business depression, now stands by virtue of its own strength.

One of the two great functions within industrial plants is production; the other is maintenance. The field of the former has been cultivated for years, and is being cultivated now, with low manufacturing costs as the harvest. The field of the latter also is capable of yielding rich harvests of low contributing cost if properly cultivated. It is in the interest of such cultivation that we shall continue our editorial efforts under the name *Maintenance Engineering.*

Applying Electron Tubes in Industry

CONSIDERING the widespread publicity that has of late been given to the dramatic performances and interesting possibilities of electron tubes, it is not surprising that a great deal of experimental work is going on in industrial plants and elsewhere. With the alluring glimpses that we have had of the possible applications of such equipment to industrial machines and processes, it is inevitable that many progressive plants and many individuals with an inventive twist of mind should turn to electron-tube equipment for the solution of troublesome problems or the betterment of existing apparatus and methods.

It was to be expected that much of this work would be veiled in deep secrecy. When one is engaged on a project that may lead to securing a worth-while advantage over competitors, or that may include a valuable patent as a reward for ingenuity and technical knowledge, garrulousness has distinct disadvantages. Too much secrecy, on the other hand, may help to defeat its own purpose.

Successful development or application of electron-tube equipment requires a considerable amount of highly technical knowledge that comparatively few possess at this time. There must be proper selection and balancing of the component parts, based on an intimate knowledge of their characteristics and limitations. Failure to recognize some of these fundamental facts, or lack of the knowledge needed to work in accordance with them, are more than likely to result in disappointment and waste of time and money. In consequence, the application of electron-tube equipment will inevitably be delayed, and faith in its possibilities badly shaken.

If one has the money and leisure to find out by experiment all of the facts he needs—well and good. However, when practical results of value are needed with the minimum expenditure of capital and effort, it is the part of wisdom to seek expert advice from the manufacturers of the equipment, or from others who are qualified to give it.

Industry's Magic Hot Stick

IN practically every sizable industrial plant there are numerous places where a small amount of heat is required for some purpose. The dies of a press may have to be warmed, a sprinkler valve or pipe kept from freezing, a watchman's shanty or crane cab made comfortable for the occupant, a drying or warming operation required by some product—there is almost no end to the variety of purposes and conditions under which a low-temperature source of heat is required.

Providing this source of heat frequently presents a problem that is unwontedly troublesome. Use of steam may either be impossible or involve running a line for a considerable distance, which

has several disadvantages. Gas may be easier to handle, but is not free from such disadvantages as fire hazard and the difficulty of obtaining sufficiently close control of the temperature and uniform distribution of heat.

Electric heating units now available constitute an almost ideal solution of many of these odd-job heating problems. These units can be had in any desired capacity from a few watts up, and in any shape—round, or ring-shaped, straight, bent, or curved in any desired way. They can be clamped onto, or imbedded in, almost any part, immersed in water or other liquids, or mounted anywhere. A power line is almost invariably nearby, and solves the problem of supply.

Rugged, self-contained, inexpensive, the electric heating units now obtainable everywhere are an interesting development of the past few years and are serving a multitude of useful purposes. Any plant man who has a heating problem on his hands will do well to look into the advantages that these devices offer.

Two Viewpoints on Maintenance—One Good

PROSPERITY may test the moral fiber of an individual or nation, but adversity puts the management policies of business establishments to no less searching a test. In the depression that we have recently experienced the need for stimulating maintenance and rehabilitation work has been widely stressed, and taken very seriously by a great many concerns. Countless plants are in better condition today, as regards equipment and buildings, than they were a year or so ago.

On the other hand, a few instances come to mind of plants wherein the management has drastically curtailed the work of the maintenance department, or placed important responsibilities in hands that are hardly qualified by experience and training to discharge them. Such penny-saving tactics can be motivated only by lamentable ignorance of the nature and importance of maintenance work. A plant may drift along for a time without skilfully directed maintenance, but a day of reckoning always comes. Neglected equipment and buildings, and failure to keep on putting in needed improvements that make an industrial plant a living, growing entity, inevitably will exact their toll in lowered morale of employees, higher costs, and lower profits.

Much more understandable and in line with modern trends is the attitude of the president of one of America's great industrial units. In a recent conversation he declared that so long as he is president of this company, appropriations for maintenance work will not be curtailed below the point of adequacy, or diverted for other purposes.

As the successful head of a successful, progressive company this man knows how important maintenance work is, and what it can do to keep his company in the very forefront of its industry.

When Modernizing Mechanical Power Drives

DURING the program of modernization that has been under way in many industrial plants, mechanical power transmission has received a good share of attention. That is as it should be, for at a time when stern necessity dictates the adoption of every machine and method that will increase efficiency and cut production costs, the need for transmitting power from prime mover to machine with the greatest all-around economy and reliability loses none of its importance. Power transmission equipment has oftentimes been responsible for many costly production delays and power losses.

If it is a mistake to keep in service transmission equipment that may have been suited to the requirements when it was installed years ago, it is also fallacious to assume that modernization of power drives always necessarily means an individual motor for each machine. Much ink and many words have been used in proclaiming the respective advantages of group and individual drives. As a matter of fact, both methods of driving have their good points and their weaknesses; each may claim superiority under certain conditions. In many cases a combination of both methods will give the best results at the lowest operating and maintenance costs. A careful analysis of all of the conditions forms the only basis on which an intelligent decision can be made.

For those who wish, or are forced by circumstances, to retain existing group drives, it may be said that much can oftentimes be done to modernize them, with a considerable increase in efficiency. If conditions make it desirable, a single drive for a large group of machines can be, as a rule, easily split up into units of any size. Furthermore, the wide use of antifriction bearings in power transmission equipment, with the improvements in belts, chains, clutches, pulleys, and every other element of such equipment has made possible economies and results that were not obtainable fifteen or twenty years ago.

Modernization of power drives is something that should be undertaken with an open mind and a firm determination to secure and analyze all of the pertinent facts.

PLANT ENGINEERS' FORUM

Here is the nineteenth of a series of questions, each of which has at least two sides. A new question will be presented next month, and our readers' answers to previous questions also will be published. Write down your opinions and send them to the editor. Answers published will be paid for at an attractive rate.

Should Maintenance Engineers Attend Conventions?

In this episode George Shipman and Frank Fulleger meet at the bowling alleys, where Frank's plant team is to oppose that of another local plant in deadly struggle. Frank is sitting on the bench, waiting for word to start, when he is joined by George, who has come to lend moral support. Shipman opens the conversation.

* * *

"Hello, Frank. In trim tonight? You'd better be, my boy—stiff competition, you know."

"Well, well—hardly thought you'd show up tonight, George. Tried several times last week to get you on the phone, but all I could learn was that you were out of town. Things so slow that you have to put in the time traveling? Or have you been taking a vacation?"

" 'No' to everything, Frank. Business is picking up. I'm needed more than ever at the plant, and I have not been on a vacation.

"I give up. What were you up to?"

"Went to a convention."

"Convention? What kind?"

"Management."

"Hm! Get anything out of it, except a good time?"

"Say I did. Got a whole headful of ideas, some of which I'll use sometime. Did have a good time, too, meeting and talking with other management people. Swapped a lot of ideas."

"Ideas, George, ideas! Do you really think the expense was justified when all you got was ideas? Didn't you get one tangible thing?"

"Now Frank, be calm. Let's don't get into that kind of argument. You should know by this time that I consider ideas tangible assets. You'd better hike over to Cleveland two weeks hence and get yourself some."

"What do you mean? Attend the Industrial Congress?"

"That's exactly it—I'm referring particularly to the Maintenance Sessions."

"Do you think I'd get something practical? Or would I have to be satisfied with ideas, just as you are?"

"You make me laugh, Frank. And you also make me weary. I happen to know that if you go you are going to hear some thoroughly practical papers. And the discussion ought to be keen. But I insist that you have no right to condemn ideas as such. I see they're calling you for the game, and that calls off our conversation. Take my advice and go to the Congress."

"Maybe I'll do it, George—just because you think I won't. Here goes a strike!"

* * *

Of course Frank's closing remark is only by way of telling George that he's going to give the suggestion a try, anyway. How do you readers of Maintenance Engineering—key men in maintenance—feel about this subject?

Is the maintenance engineer justified in attending conventions that deal directly with his field?

Make your answers short and to the point. Hold them below 300 words if you can.

(Answers to previous questions start on the following page)

READERS' ANSWERS

To Previous Questions

To Whom Should the Maintenance Department Report?

Question presented in the March Issue)

THE maintenance department is a unit of a factory system, as much so as are the production, office, and sales departments. To my mind there would be as much logic in the maintenance department reporting to the office or sales managers, as to the production manager.

Undoubtedly, the maintenance department should report to the superintendent or manager, because they are the heads of the entire system, which as a whole is ministered to by the maintenance department.

The work of the maintenance or plant engineer, while perhaps primarily to maintain production, is not confined to that alone. Many other activities are within his line of duty, the general function of which is to maintain the company's property as a whole, in efficient working order, and to minimize its depreciation.

The production manager usually is too busy attending to scheduling his work and planning operations to be bothered with the responsibility of maintaining the machinery. This function were better left to a specialist, such as the plant engineer, who should favor none and serve all.

JOHN S. ISDALE, *Plant Engineer*
International Silver Company
Meriden, Conn.

MAINTENANCE department reports that go direct to the management tend to provide the best all-around satisfaction. While not admitting that it is essential for the management to have these reports in cases where the maintenance work is small and of a minor nature, it certainly is a great advantage in determining overhead. An accident or shut-down usually will reveal to the management the importance of maintenance work.

While there are times when troubles that may be classed as accidents occur, the majority of such troubles are caused by small things. A maintenance man, trained in the shop, has a keen perception of these small things, which a production manager probably would think of as inconsequential, and neglect. Ordinarily, there would be few occurrences that would be considered as unavoidable, if the maintenance department reported. to the management all findings made during the routine inspection. Difficulties that thus arise may be dealt with as part of the general routine, or may be of such character as to require extreme measures.

In emergency situations that object usually is to restore operating conditions as quickly as possible. Expense is subordinated. The personal interest of the management secures supervision of the highest order. In the limelight that surrounds such activities the ordinary routine maintenance, of which the management has heard little, appears to be vastly important.

The major responsibility for successful plant operations always must follow the routine of regular operations and of taking measures in time to prevent what might later develop into emergency situations. All of the facts need to be brought to the attention of the management or a true description of the existing condition is not given.

The pathway from the fuel to the finished product can be made a smooth, unobstructed highway, if the management will direct the production and maintenance schedules, permitting advancement of one ahead of the other only as the best interests dictate.

WILLIAM ANDERSON, *Pipe Shop Foreman*
E. W. Bliss Company, Brooklyn, N. Y.

THE maintenance department should report directly to the management. In nearly all plants production problems require the undivided attention of the production forces. Why should the production men be expected to scatter their shot, when concentration is the watchword today?

Likewise, the maintenance department should concentrate on its problems, spending considerable time on the preventive maintenance program. This program requires a knowledge of the accepted method of handling repairs, as well as of the technical progress in the art associated with plant processes and plant machinery. The proper inspection schedules for routine care and cleaning, general overhauling, plus a judicious program of motor testing to search out mechanical defects, all deserve intelligent and sympathetic attention. As a result of inspections, it may be found that complete redesign is necessary.

Logical development of the maintenance department is along the line of an independent organization, capable of handling the complex problems involved. Industry is rapidly adopting the plan of placing maintenance directly under the supervision of the management.

J. ELMER HOUSLEY, *Electrical Superintendent*
Aluminum Company of America
Alcoa, Tenn.

How Valuable Are Plant Visits?

(Question presented in the February Issue)

IT appears from Frank's remarks that he did not appreciate his good fortune in having his employers finance his trips to other plants. When a man gets the idea that his knowledge and methods are beyond improvement, he ceases to be an asset to a firm.

I firmly believe that any firm is justified in financing trips of employees on visits to other plants for educational purposes, not to steal ideas, but to be of mutual benefit. No matter how good our methods are, seeing how someone else has surmounted similar difficulties often leads to an improvement, or shows a short-cut.

I have in mind a chance visit by an official of our firm to a plant located several hundred miles away, where the products were similar. This visit saved our firm hundreds of dollars because of the simplified design of some improvements we were making in lumber handling methods. Since this installation, the same official, while on vacation, observed at another plant still greater refinements, that will eliminate one man from the crew when incorporated in our design. The direct saving in the cost of this one improvement would pay the expenses of monthly trips for some key man as long as it is in operation.

GEORGE R. MILLER, *Head Millwright*
Pacific Lumber Company
Scotia, Calif.

A GREAT deal can be accomplished by visiting other plants. When a man is freed of the grind and routine of daily duties his mind is more alert and receptive to new ideas and methods, and the best place to get such ideas is in the other fellow's plant.

I remember, on a trip I took several years ago, running across a man crating machinery. The results of that casual meeting meant, to our company, a 32 per cent reduction in crating material and an approximate decrease of 40 per cent in labor costs.

If you harbor a preconceived notion that your machines or methods are better than your neighbor's, a trip around the country, visiting other plants, will be found decidedly profitable, both to you and to your company. A. C. NOLKE, *Chief Time-Study Engineer*
Harnischfeger Corporation
Milwaukee, Wis.

Bonus for Maintenance?

(Question presented in the January Issue)

THE maintenance crew is as much entitled to share in the results of good work faithfully performed as are the production crews.

I do not believe in a bonus system based on a ratio of production man-hours to maintenance man-hours, nor one based on a production unit ratio to maintenance man-hours. These two methods work all right only with full production. Deterioration, and therefore maintenance, go on during dull times.

I believe in a maintenance bonus system based on the principle of inspection and task setting for each job. The organization set-up would be as follows: A work-order clerk, a task setter, stores clerk, delivery-to-job service, time clerk.

An approved order comes into the maintenance office. It is passed to the task setter, receiving his routine attention unless it covers an emergency. The task setter goes to the job to determine the actual work to be done, fills out a form specifying the operations required, men needed, time allowed, and material required.

With the task setter's instructions attached the order is sent to the stores clerk who fills the material requirements and returns the order to the work-order clerk with notification that material is ready for delivery.

The work-order clerk notifies the delivery service to deliver the material to the job, and assigns the man or men to do the work. A card made out by the time clerk is given each man, the man punches his card "in" and "out." The time clerk figures the man-hours put in on the job and sets the bonus to be paid, this bonus to be a certain percentage of the time saved on the job.

FREDERICK W. CARTER
In Charge of Power and Maintenance
Waterbury Clock Company
Waterbury, Conn.

Who Shall Specify Equipment?

(Question presented in the October Issue)

THERE should be a complete understanding between maintenance and purchasing departments as to specifications. The maintenance engineer should specify the mechanical requirements, and the manufacturer's name if necessary, and call upon the purchasing department to get the best prices on this equipment.

Should the purchasing agent believe that he knows of other suitable equipment at lower price he should inform the maintenance engineer who will accept or reject. In no case should the purchasing agent or his department change the specifications. Sometimes a certain make of equipment is ordered because no other will do, and if a substitute arrives there is trouble all around. M. C. COCKSHOTT, *M. G. Gill Corporation*
Long Beach, Calif.

IT is possible for both the purchasing agent and the requisitioner to specify equipment, if it is done in a spirit of co-operation. If any plant has a problem as presented, a method used by a prominent manufacturer might be of interest. His requisition form has a space on it for the requisitioner to tell just why he wants certain material.

When things are ordered in this way it gives the purchasing agent a chance to inform competitive manufacturers of this article, who may be selling it cheaper than the firm specified, just what the requirements are and what only will be accepted. They may be able to meet the specifications at a distinct saving to the firm.

There should be no autocracy about it one way or another, for on the other side of the question we must not forget that the purchasing agent is better situated to know what is going on in the market. While we have a feeling that the article we specify is the only one for the job, he may, by knowing what we want and why we want that particular kind, be able to show us something as good or better at a saving. On the other hand, no purchasing agent will deliberately buy an inferior article when he knows what is expected. Each man in his own place is a distinct asset to the employer, and the man who is responsible for expenditures certainly has the right to know what it is all about.

CHAS. R. WHITEHOUSE, *Standards Engineer*
The Holtzer Cabot Electric Company
Boston, Mass.

QUESTIONS and ANSWERS

Changing Speed of Slipring Motor

I have a G.E. slipring motor, type MTC 5201, form C, 1,200 r.p.m., and want to speed it up by changing it to a four-pole machine. There are 72 slots in the stator and 54 slots in the rotor. The coil span of the stator is 1 to 11, and 1 to 10 in the rotor. Is this change practicable? Will the coil span or number of turns in the winding have to be changed? If so, what will the new data be? Any information you can give me will be appreciated.

Birmingham, Ala. T. F. T.

■

Removing Rusty Fittings from Pipe

From time to time considerable quantities of iron pipe of all sizes up to about 3 in. accumulate in our scrap pile. We try to salvage as much as we can, particularly the brass and iron fittings and valves. However, it is often practically impossible to remove fittings that have become rusted on, although they are otherwise in good condition. I wish that readers would tell me the methods they have found most effective in loosening up rusty valves and fittings, so that they can be removed without too much distortion and effort.

Milwaukee, Wis. P. J. D.

■

Marking Traffic Lines on Floors

Considerable difficulty has been experienced in working out a satisfactory method of marking traffic lanes and the like on our floors. Lines painted on the floors soon become obliterated; furthermore, our floors are largely of wood, although some concrete is used, and inasmuch as the wood is quite oily it is sometimes difficul to make paint adhere. Metal markers have been tried and were fairly satisfactory, although the expense of properly installing the type we used was high. What are the best methods that other readers have found for marking floors subjected to trucking and rather heavy traffic?

Boston, Mass. E. P. S.

Please submit answers promptly. We expect to publish no answers later than the second issue following the appearance of the question. Selection will be made on the basis of quality, but answers first received have the best chance of being used.

Rewound D. C. Motor Operates at Half Speed

We have a 500-volt, 50-hp., Westinghouse Type S No. 10, 825-r.p.m., d.c. motor; the markings on the commutator end of the shaft are: No. 365913—35754—135B—No. 10—S. This motor has four shunt and four series fields. The shunt and series field coils are connected for our line voltage of 250 volts. Recently the armature was rewound, but when it was stripped we failed to check certain connections to the commutator. When reassembled the motor ran at about half speed. So far as I know the turns, size of wire, coil throw and lead throw are the same as before and I should like to know where our mistake is and how to remedy it so that we can obtain the full speed again.

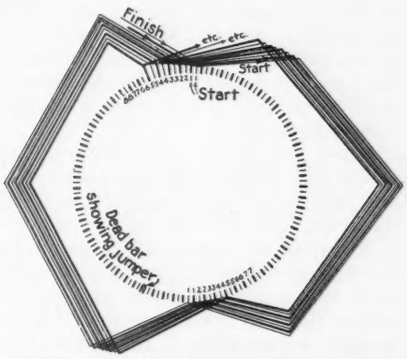
Carteret, N. J. W. C.

IN MY opinion the answer given in the March issue to W.C.'s question is rather misleading. On d.c. machines of this speed, the speed can be varied only about 75 to 100 r.p.m. between the minimum and maximum speeds without causing destructive sparking at the brushes. At the voltage given a flashover between holders would probably take place.

As W.C. states that his machine was originally designed for 500 volts, and that it now runs at half speed, I believe the armature is now wound and connected for 500 volts, instead of 250 volts. When the armature was stripped it was probably a two-circuit connection, instead of one-circuit, as is normally the case. This method of paralleling an armature is sometimes used by a repairman when changing a motor for a lower voltage, but requires great care.

From the numbers on the end of the shaft, it will be seen that there are 135 bars in the commutator. It can readily be changed into a two-circuit armature without much work. First kill one coil, as shown in the drawing, making in reality only 134 bars. A jumper should be connected to the dead bar and to a bar on one side of it, so as to connect this bar to one of the circuits. The throw of the leads should then be changed to 1 and 67. Calling the bar the top lead is in No. 1, the bottom lead should be in No. 67, counting across the span of the coil. If the dead bar is in this count, consider the two bars that are jumped together as one bar.

When all the leads have been connected 1 and 67, a test lamp will light at every other bar all around the commutator, making two complete, separate circuits. The brushes cover at least two



Scheme of connections for changing single-circuit armature to two-circuit, by killing one coil.

adjacent bars; so both circuits will be working at the same time, giving the same condition as though the armature had been rewound with one-half the number of turns, and twice the size of wire.

W.C. would have had to make a mistake of only one bar in counting the throw of the leads, as a one-circuit winding would be connected for a 1-and-68 throw.

If he changes the throw of the leads on this armature, in order to make a two-circuit connection, he should remember that the brush holders on a

Westinghouse motor of this size are fastened directly to the head and can be shifted only about 1 in. He should use his own judgment as to whether to change the top or bottom lead one bar or two, in order to keep the brushholders in proper relation to the coil undergoing commutation. This means that the brushes should be on the bars that contain the top leads of the coils midway between the polepieces.

There are certain conditions in a wave winding wherein it would not be advisable to change the armature to a two-circuit connection; hence, unless the winder knows what he is doing, and thoroughly understands direct-current connections he should not attempt to parallel an armature in this way without securing a drawing or advice from the manufacturer. GEO. D. RINGNESS.

Foremost Electric Company,
Peoria, Ill.

W. C. did not state the number of bars and coils and giving an answer is difficult. I suggest that he check his connections to the commutator in regard to the type of winding used.

I assume he has used a single-wave (2-circuit) connection instead of double-wave (4-circuit), which would give one-half armature speed with fields and other connections remaining the same.

Some time ago I had a 40-hp. armature wound with rectangular wire coils. The coils had been stripped from the armature before coming to the shop so I did not have the data of lead span to the commutator. There were 172 commutator bars and 43 coil bundles of 4 coils each, making 172 coils. In winding this armature I killed one coil and one bar so that I could use a single-wave connection.

After assembling and testing this motor I discovered the speed was only one-half the original speed. Checking the winding over I found I could use a double-wave instead of single wave winding by using 172 bars and 172 coils, so I raised the top leads and reconnected them to the commutator which brought the armature to full speed.

Chief Electrician A. E. RUSTON.
Hocking Valley Mine Supply Company
Athens, Ohio

■

How Much Can Belts Be Twisted Without Injury?

By placing several groups of machines at an angle to, instead of parallel with, the lineshaft that drives them, we can save space. Placing the machines at an angle will mean twisting the belts, which I suppose increases the wear and tear. Our belts are heavy single-ply, oak-tanned, 5 in. wide. Lineshaft pulleys are 30 in. in diameter: the machine pulleys are 12 in. in diameter. Lineshaft speed is 220 r.p.m. The drives are practically vertical. Center distance between line- and machine shafts is about 10 ft. Can readers tell me approximately the maximum angle between the line- and machine shafts at which these belts can be operated without seriously shortening their life or increasing maintenance costs?

Minneapolis, Minn. **J. Q. C.**

BELTS may be twisted and run successfully up to a quarter or 90 deg. turn if necessary, but, in cases in which the center distance is less than 25 times the width of the belt, one edge of the belt must be longer than the other. This is necessary in order that the belt will not hump up or pucker on the pulleys, but lie flat against the pulley faces. Most single belts have a backbone along one side; this backbone edge should be run on the short side of the drive.

J. Q. C.'s method of saving space by placing machines on an angle is common practice in the arrangement of screw machine drives. The screw machines are usually placed at an angle of 15 deg. to the line shaft. This line-up conserves most of the space formerly occupied by the overhanging bar stock.

JOHN S. ISDALE.

Plant Engineer, Factory K
International Silver Company
Meriden, Conn.

■

Corrosion of Water Pipes

We are having considerable trouble from the rapid rusting out or clogging of the galvanized pipe used in some of our water lines. So far we have used ordinary galvanized iron pipe obtained from a local plumbing supply house. Most of the trouble is experienced with the ¾-in. and 1-in. lines that supply individual machines. We have both hot and cold water lines. The hot water lines seem to deteriorate faster than those carrying cold water. Accurate records of replacements have not been kept, but it appears that the average life of the smaller size of pipe is from one and one-half to three years.

We do not want to incur the expense of installing brass piping throughout, and I am wondering if there is available any kind of pipe, possibly made from some new iron alloy, that is intermediate in cost and has corrosion-resisting properties between brass and galvanized iron pipe. Can readers enlighten me on this subject?

New York, N. Y. **W. A. M.**

RAPID corrosion of some of W.A.M.'s pipe lines is not an exceptional or isolated condition confined only to his plant. Maintenance engineers in many branches of industry are recognizing the high cost of pipe maintenance, due either to improper selection of material at the time of installing the piping system, or to changing water conditions.

Contrary to general opinion, many failures are not the result of faulty piping materials, but are due rather to the selection of the wrong kind of pipe to cope with certain operating conditions. These different problems are mounting rapidly, owing to many changing conditions which herald industrial growth.

No longer can an engineer who utilizes the same kind of piping material wherever the need for pipe may arise, expect satisfactory results. The increase in the magnitude and the more involved nature of manufacturing processes has made the purchase of pipe a highly-specialized responsibility.

Many factors in each application enter into the determination of the life of piping material. When installing new pipe, or making replacements, detailed consideration should be given to the conditions under which that pipe must serve. In addition, the service performed by various piping materials under similar conditions is an excellent guide to the selection of the most suitable material for a given job.

Where experience fails as a guide, a carefully-interpreted analysis of the water or corrosive agent is easily justified. When we consider that the properties of water within the confines of a city block may differ to the extent that a marked difference in corrosion can be detected, it can easily be seen why this point is important.

In considering the possible greater corrosion-resisting properties of alloyed piping material, W.A.M. has taken the first step toward prescribing for the unhealthy condition of his pipe lines. Before going any further he should make a careful study of the symptoms or local conditions, which will give him the true answer to the best pipe with which to make replacements. It may be that the cheapest available pipe will be the most economical; or it may be the other extreme, where lowest maintenance comes with the highest material expense.

It would be dangerous to make a blanket recommendation without knowing more about local conditions at the plant in question. In case W.A.M. is not familiar with what different kinds of pipe have done under certain operating conditions in the past, I would suggest that he get in touch with one of the large manufacturers of steel or wrought-iron pipe, who maintain field engineering service organizations.

Chief Chemist, F. E. ECKERT.
A. M. Byers Company,
Pittsburgh, Pa.

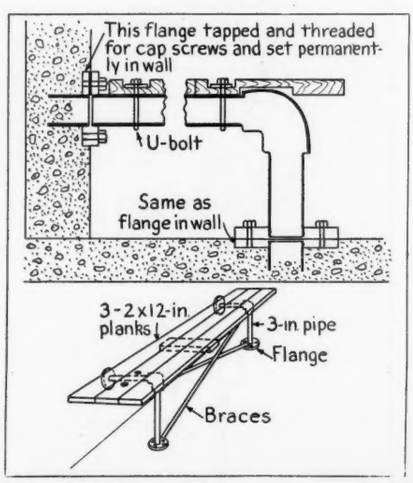
AROUND the WORKS

A section devoted to short articles describing practical methods devised to meet specific operating conditions. The items may refer to details of installation, inspection and testing for maintenance, wiring, repair, and replacement.

Placements Provide Quick Work-Bench Set-up

PERMANENT work benches are a necessity in repair and maintenance work, but at other times are a nuisance and a bother. Often the emergency can be met by using sawhorses, but these are not altogether satisfactory because they do not provide a rigid support on which to work. We have overcome these drawbacks by means of pipe supports which bolt onto flanges already set in the floors and walls.

These permanent flange supports are placed wherever we have occasion to do work. In new buildings under construction we put them where we think they



When the bench is set up the supports are bolted to the wall flanges. The planks are then bolted to the supports with U-bolts in countersunk holes. As a rule, these U-bolts are not disturbed when the bench is moved, that is, the entire bench is moved as a unit.

are necessary. The job is done on a building work order as it is considered a part of the permanent structure.

We have found that three-inch pipe provides the necessary rigidity and holds satisfactorily. The bench top, as shown, is made up of three 2x12-in. planks, each 12 ft. long, and to which the pipe vice remains permanently attached. The pipe supports, with each leg 30 in. long makes up a bench about 32 in. high. The edge of the bench top slightly overhangs the supports.

To make sure the flanges set in the walls and floors are in the right location and line up properly, they are bolted to the support pipes. The wall and floor is then poured and allowed to set before the supports are removed.

Brooklyn, N. Y. P. F. ROGERS.

■

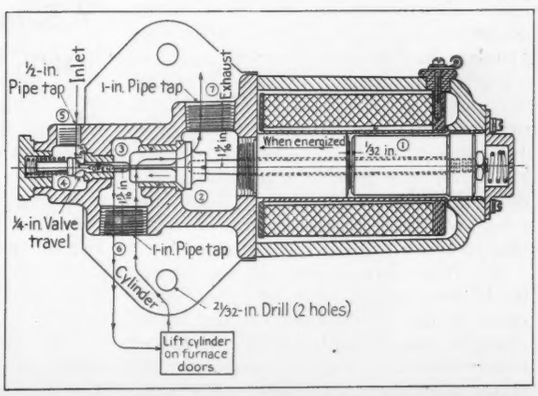
Modified Control Simplifies Furnace Door Operation

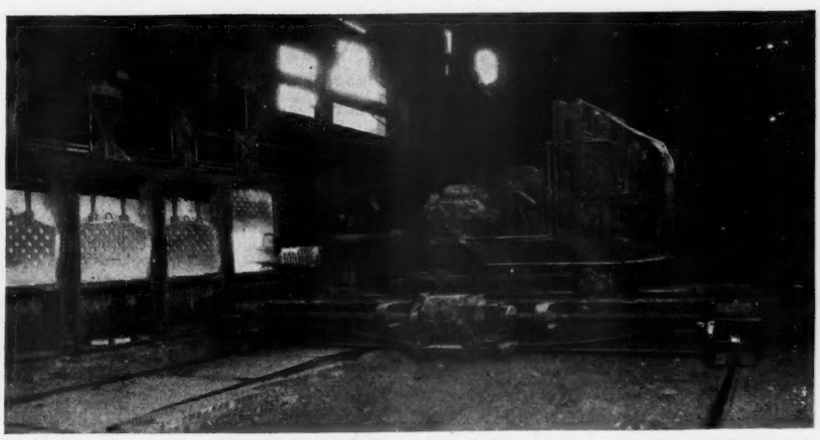
SOME time ago a change was suggested in the door-operating mechanism of a number of furnaces of early design. These furnaces were used in heating material to be processed, and which were served by a charging machine.

Their power-lift doors were air operated and controlled from a station on signal from the charging-machine operator. As shown in the accompanying illustration, the air cylinders are located above the doors. The change suggested was to replace this equipment with motor-driven apparatus, but it was found that little could be gained unless some way could be devised to eliminate the labor expense of the operators.

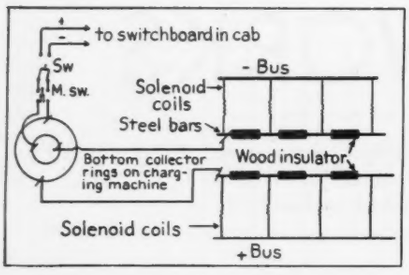
A simple way was found to satisfy that point and still make a change with little expense; a change that really improved operations. The air-lift features were retained, but they were modified through the use of magnetically operated air valves, the operation of which became the duty of the charging-machine operator instead of the former door tenders.

Sequence of operation of magnet valves on furnace doors. Armature 1, when energized closes valve 2, and also opens valve 4, permitting compressed air to flow to the air cylinder through ports 5, 3, and 6. When the coil is de-energized the spring-assisted air-valve 4 closes; valve 2 opens, releasing air from the cylinder, through port 7.





These furnace doors are opened and closed by the charging machine operator.



Wiring diagram of door-opening circuits.

With the addition of extra collector rings on the charging machine the cab control was made common to every door circuit in the conductor pit.

These installations involved the use of 32 valves which released six men for duty elsewhere in the plant, and, in addition, the total investment was fully realized in an operating period of 65 days, as against 3½ years for the motor-driven equipment.

J. S. MURRAY.
Electrical Engineer
Follansbee Brothers Company
Follansbee, W. Va.

■

Turning a Large Rotor Under Difficulties

WE had considerable trouble from time to time with the rotor of a 1,200-hp., three-phase, 60-cycle, 250-r.p.m. slipring motor that was direct connected to a line of three large pulp grinders in the wood grinding room of a paper mill, through the rotor rubbing the stator in different places. Special care was taken in adjusting the air gap and periodical inspections were made, but a hot spot would be found and the indications showed plainly that the rotor was rubbing, although it never rubbed twice in the same place.

We have found spots at the top, at the bottom, and on either side and finally came to the conclusion that the stator changed shape slightly with changes of temperature as it was impossible for the stator to move on its base. The same was true of the rotor pedestals as they were securely doweled and bolted. Finally it was decided to take a cut of 0.025 in. from the rotor and thereby increase the air-gap clearance. It was inadvisable to put a tool on the laminations and take a cut so the method decided on was to grind the peripheral surface of the rotor with a heavy-duty grinder.

Some difficulty was encountered to find a means of turning the rotor slowly and steadily. The following method of driving the rotor was laid out and installed. The end of the rotor shaft was drilled and tapped to take eight ⅝-in. cap screws. A half coupling or coupling flange with a piece of shaft keyed to the coupling was bolted securely to the end of the rotor. This short piece of shaft carried a large gear. Another shaft with a large and small gear were arranged so that a small pinion gear was in mesh with the large gear on the shaft attached by the coupling. A 10-hp. vertical steam engine was set up with a small gear on the crank shaft meshing into the large gear on what would commonly be called the intermediate shaft. A rotor speed of 4 r.p.m. or more as desired was obtained by changing the speed of the steam engine.

This rotor measured over 10 ft. in diameter and at 4 r.p.m. gave us approximately 132 f.p.m. for grinding which proved to be a satisfactory speed.

The grinder used was a heavy-duty unit set up on a compound rest. A 12x 1¼-in. medium coarse grit carborundum stone was used. The cuts taken by the grinder averaged between 0.006 and 0.007 in. Four separate cuts were taken off, which resulted in approximately 0.025 in. being removed from the rotor laminations. This amount was deemed sufficient for ample air-gap clearance under all operating conditions.

It was the only practical way we could find to do this job under the existing conditions because the rotor was much too large to be moved. Now we are sure of always maintaining ample air gap space and thus reduce the chances of hot spots and damaged coils.

LEE F. DANN.
Dounacona, Quebec, Can.

■

A Sure-Gripping, Inexpensive, Pipe-Joint Cement

AN inexpensive pipe cement of quality for the millwright or shop pipe fitter can be made by following this formula:

Special zinc dust, 12¼ lb.; "Double-boiled" oil, 3 lb.; "Dry Mago," ¾ lb. The oil is heated and the Dry Mago is stirred into it. Next is added the zinc dust which also is stirred in. Let the mixture set for 24 hours.

This cement will give tight joints for water, steam, air or chemicals. When it is necessary to open a pipe line for repairs, the joints can be loosened with a wrench.

CHARLES R. WHITEHOUSE.
Standards Engineer
The Holtzer-Cabot Electric Company
Boston, Mass.

■

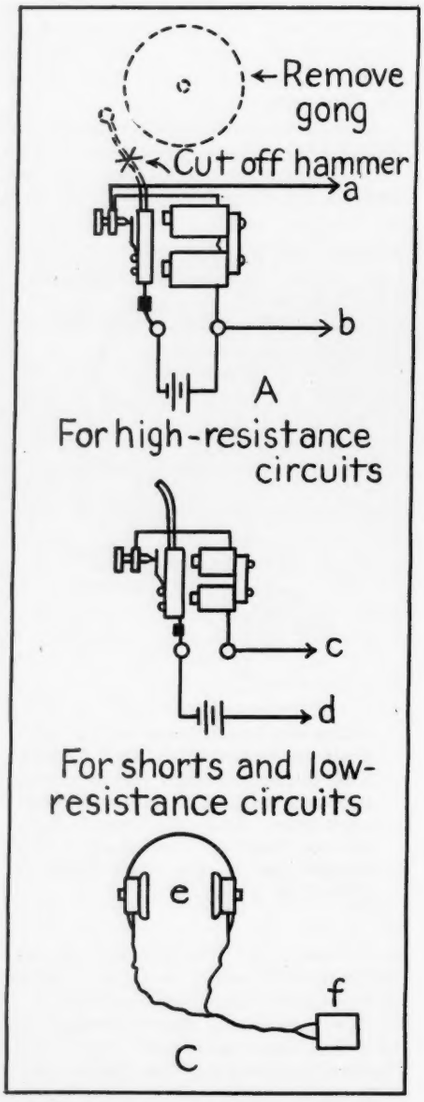
Trouble Finder for Telephone Cables

MANY plants have considerable telephone cable installed, and as expansion takes place it often becomes imperative to utilize every possible conductor in these cables. Conductors that have become open, shorted, or grounded are often difficult to clear without suitable instruments. The accompanying sketches show a hastily constructed set of instruments that will positively indicate the exact spot where the trouble is located, so that it will not be necessary to open the cable except at these points.

Sketch *A* shows an ordinary door bell which is used to send out an interrupted current over the faulty lines. The connection shown is used for high-resistance circuits whereas the connection shown at *B* is used for low-resistance circuits. Sketch *C* shows the exploring coil which consists of a headset used for radio reception. The coil is a 4-ohm telephone drop coil, or any similar coil, well taped to protect it from rough handling. All joints should be soldered.

In actual use the exploring coil is held against the cable and moved along it until the trouble is located. A decided humming is heard in the headset as the coil is moved along the cable. When the fault is reached the humming stops.

CHAS. A. PETERSON.
Cold Spring, Minn.



Parts and connections of trouble finder for detecting faults in plant telephone cables.

EQUIPMENT NEWS

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these devices, which are designed to improve plant operation or reduce operating and maintenance costs.

National Wood-Block Flooring

NATIONAL Wood Products Company, a subsidiary of Evans Auto Loading Company, Detroit, Mich., announces a line of wood-block flooring called "Evanite."

A special, heavy-duty block for herringbone patterns is made for industrial purposes. Blocks may be obtained in various grade combinations, resulting in variegated colors for purpose of contrast, and in geometrical or modernistic patterns. They are laid in cushionite mastic composition. Other features are: dowel-pin construction, treatment with transparent Pen-O-Treat wood preservative, and an interlocking joint which effects a lock on all four sides when assembled with other blocks. This joint

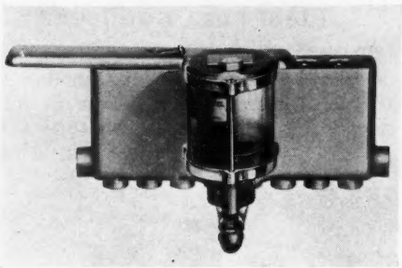
is said to permit laying a block without disturbing the mastic beneath.

Standard thickness is $\frac{25}{32}$ in., but blocks may be obtained up to $1\frac{1}{16}$ in. Standard sizes are 6x6 in., 9x9 in., and 12x12 in. Oak, maple, beech, and birch blocks are available.

■

Daun-Walter Lubrication Unit

CONTROL of the amount of oil delivered from a reserve supply of from ½ pt. to 2 gal., is accomplished by a device announced by the Daun-Walter Company, Milwaukee, Wis. This device, known as the adjustable-wick oil-feed unit, has no moving parts, and is said to provide a positive, continuous control over the quantity of oil fed each bearing. It consists of two elements, the



constant-level oil control, which provides oil storage and maintains a constant oil level in the wick chamber, and the adjustable-wick oil-feed multiple unit, or wick box.

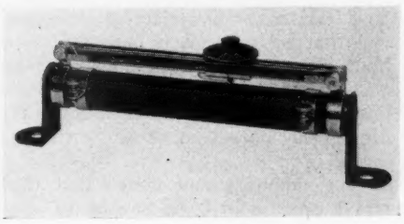
The wick box is cast aluminum, with a removable cover, and is available with 4, 8, and 12 outlets. A number of wick boxes on the same level may be hooked up by joining the horizontal outlets on either end. Provision is made for adjusting the height of the turn-down of each wick loop, which determines the quantity of oil fed by the wick, since the level of the oil in the wick chamber is permanently stationary. A minimum flow of four drops per hr. can be maintained continuously.

■

Ohmite Slide-Wire Rheostat and Potentiometer

A PERCENTAGE-of-resistance scale and a contact screw are incorporated in the slide-wire rheostat and potentiometer made by the Ohmite Manufacturing Company, 636 North Albany Ave., Chicago, Ill. Percentage-of-resistance is indicated by a scale across the top of the frame. This enables the operator to obtain a close approximation of the resistance in the circuit without removing the rheostat and measuring it on a bridge.

The screw arrangement allows the operator to set the phosphor-bronze spring at any desired point, making certain of accurate consecutive readings.



Units have a maximum rating of 50 watts when all the resistance winding is in the circuit. Ten different values are available.

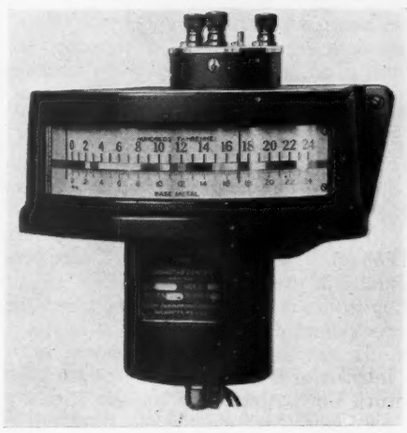
A bakelite disk insulates the worker's hand from the live portion of the rheostat. All electrical parts are nickel-plated while the mounting-brackets, which are electrically insulated, have a black enamel finish.

■

Taylor "Tycos" Pyrometer Control

TAYLOR Instrument Companies, Rochester, N. Y., announce that they have redesigned their indicating pyrometer control, known as the "Tycos" unit.

Among the added features are: A de-



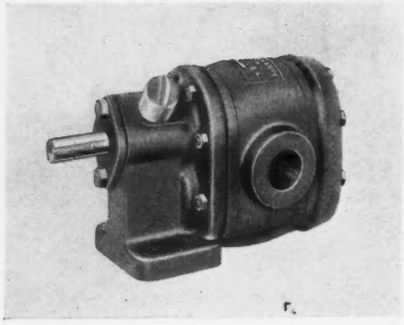
crease of 3 lb. in weight, elimination of the back panel to simplify wiring and installation and quieter operation.

■

Brown & Sharpe Rotary Geared Pump

NO. 55 rotary geared pump with ball bearings and spiral gears, has been announced by the Brown & Sharpe Manufacturing Company, Providence, R. I., to replace the No. 5 pump previously made by this company.

According to the announcement, several improvements in design and construction make this pump particularly



desirable for supplying oil under pressure for hydraulic operation of machines. Caps, stands and housings have been made heavier. To strengthen the pumps, two more bolts have been added. The suction port, including the pipe tap, has been made larger to permit a freer admittance of oil.

The pump, running from 300 to 1,200 r.p.m., is capable of delivering from 9 to 36 gal. of oil per minute at zero pressure. At 1,200 r.p.m., it delivers approximately 36 g.p.m. at 100-lb. pressure.

■

SpeedWay Pipe Threader

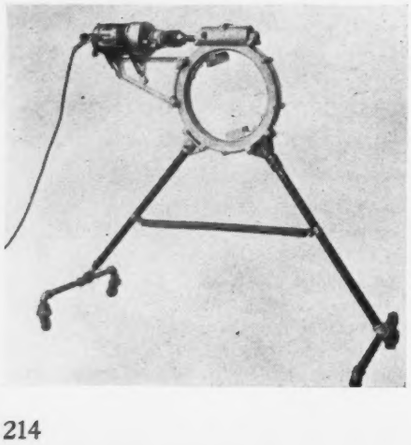
THIS machine, known as the SpeedWay Type 450 pipe threader, announced by the SpeedWay Manufacturing Company, Cicero, Ill., may be used either as a portable, electric pipe threader or a heavy-duty, ¾-in. capacity electric drill. The drill may be removed from the pipe threading part by unscrewing two thumbscrews.

When used as a power pipe threader, the Jacobs chuck on the drill grips a steel shank protruding from a universal joint.

It is claimed that this machine has enough power to thread up to 4-in. pipe, and will use any standard stock and die up to the maximum eccentric of a 4-in., compound die stock.

In operation, the wings, shown on the interior of the circle in the pipe threader, turn slowly until they connect with nipple length ends on the die stock. Here the wings catch the handles and continue to turn the stock until the power is shut off. Power control is provided by means of a switch located in the handle of the drill. Threads must be started by hand, and must be oiled during the operation of the machine.

The machine has a maximum height of 53 in., a minimum height of 33 in., a no-load speed of 20 r.p.m., and weighs 85 pounds.



■

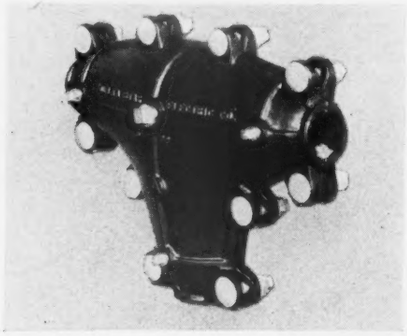
Ideal Fuse Reducer

IDEAL Commutator Dresser Company, Sycamore, Ill., has announced the Ideal fuse reducer. These devices are used when a circuit is over-fused, and are made in different sizes to fit the fuse gap of the larger fuses replaced.

■

Delta-Star Splice Boxes

SPLICE boxes for all commercial cable sizes, either leaded, armored, or trenchlay, have been announced by The Delta-Star Electric Company, 2400 Block, Fulton St., Chicago, Ill. They are obtainable in three styles; the two-way splice, the three-way tee (shown in the illustration), and the four-way cross.



Boxes are furnished in plain gray iron, galvanized, malleable iron, or non-magnetic corrosion-resisting aluminum alloy for heavy-duty a.c. service.

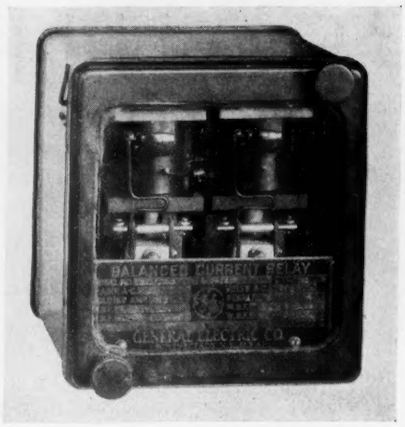
Some features of this line are, square locking shoulders on the clamping bolts, ribbed bodies, and separate end compartments adjacent to the central section, each with its own filling plug, where the armor or protective braid of the cable may be terminated.

■

General Electric High-Speed Relays

HIGH-SPEED, selective, balanced-current relays have been announced by the General Electric Company, Schenectady, N. Y., for use on a.c. parallel lines where stability is dependent upon high-speed operation of protective devices.

The announcement states that these relays operate in 0.008 second to assist



in clearing a phase-to-phase or ground fault. It also states that the use of voltage restraint allows operation below full-load current of the circuit, and permits the switching of individual transmission lines without the special operating rules ordinarily required for lines using balanced-current relays.

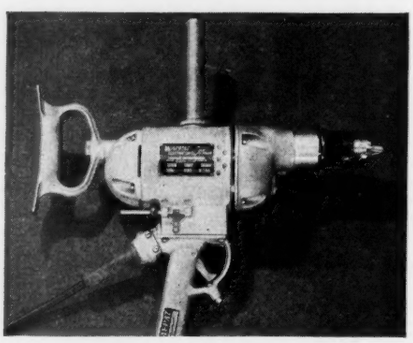
The relay is comprised of two balanced-beam units mounted in a rectangular case, 5½x6 in. Each unit consists of an armature, a set of circuit-closing contacts, and four coils.

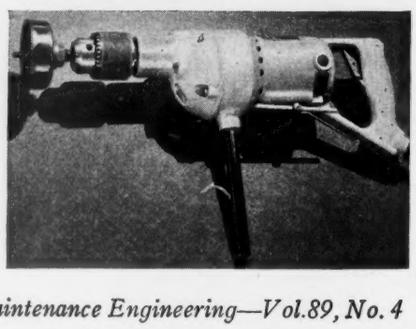
■

Wappat Drills

TWO portable electric drills, introduced by Wappat Incorporated, 7522-26 Meade St., Pittsburgh, Pa., the electric tool division of Simonds Saw and Steel Company, are the Wappat "Red Streak" slow-speed drill, and the Wappat "Red Streak" ½-in. standard-duty drill.

The slow speed unit is particularly adapted for using hole saws up to 3-in.





diameter, and for drilling hard metals such as the chrome-nickel alloy steels, Allegheny metal, and stainless steel. The drill has a full load speed of 200 r.p.m., and weighs 10 pounds.

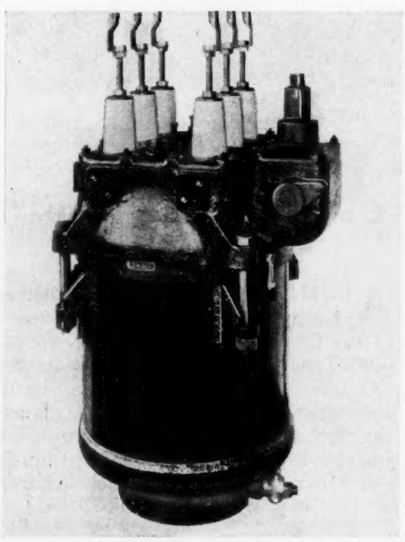
The ½-in. standard-duty drill is a utility tool for general maintenance drilling. It has a full-load speed of 248 r.p.m., and weighs 14¼ pounds.

Both these drills are equipped with three-wire cable with ground, an extra-capacity, double-pole, momentary-type switch, and helical gears of heat-treated alloy steel.

■

Condit Indoor Oil Circuit Breaker

INDOOR oil circuit breakers bearing the designation Type DR-60 have been announced by the Condit Electrical Manufacturing Corporation, Hyde Park Station, Boston, Mass. Some of the features of this equipment are: all poles are in one tank; mechanism is totally inclosed; a gasketed joint between tank



and frame; oil and gas separator and loop contacts.

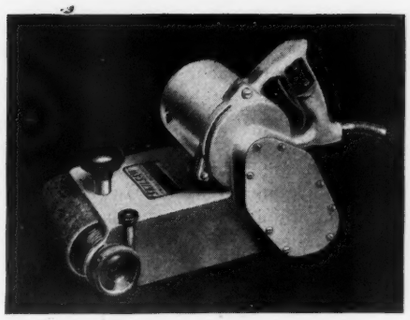
Units are furnished in three-pole types, manually or electrically operated, for 600 and 1,200 amp., 15,000 volts, with an estimated interrupting capacity of 6,000 amperes.

■

Skilsaw Sanding Machine

ANNOUNCEMENT is made, by Skilsaw, Inc., 3310 Elston Ave., Chicago, Ill., of a belt-type sanding machine for use on wood, metal, or stone. It is called the Skilsaw portable electric sander.

The front roller is adjustable on an eccentric shaft with spring tension. Tension is controlled by a handwheel on the



side of the machine. Adjustment of a thumbscrew aligns the belt on the rollers. A flexible pad permits variation in finish.

The frame is made of die-cast aluminum. The universal motor is air cooled by a centrifugal fan and operates from any light socket.

■

Ideal Grinders

DESIGN changes in two commutator and slipring precision grinders have been announced by the Ideal Commutator Dresser Company, Sycamore, Ill. In the "Perfect" model, the screw, formerly in the center, has been moved to the back of the bedplate. The head now rides on a solid plate instead of rails. One plate holds the stone tools, replacing the former clamps. A cross-feed handle of the lathe style has been substituted for the wheel type.

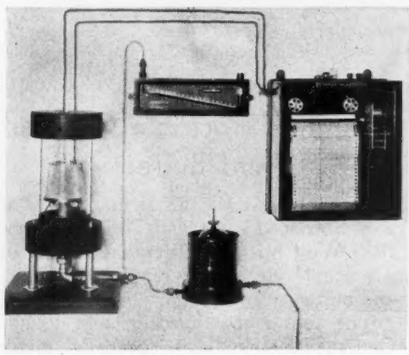
Changes in the "Ideal" model include: reversal of the rack gear position and the introduction of a star knob handle in place of the wheel or lathe type handle.

■

Brown Flame Analyzer

AN instrument for checking the heating effect of fuel gas, called the Brown flame analyzer, has been developed by the Brown Instrument Company, Philadelphia, Pa. It is said to measure, record, and automatically control the heating effect of any gas.

The illustration shows the instrument together with the recording pyrometer and a pressure governor and gage to control the flow through the analyzer.



Reeves Inclosed Variable-Speed Transmission

ANNOUNCEMENT is made by the Reeves Pulley Company, Columbus, Ind., of an inclosed design variable-speed transmission.

Internal operating parts are totally inclosed in a cast-iron case, which, according to the announcement, affords complete protection in all machine applications, in which the operating parts of the transmission must be guarded from water, live steam, chemical fumes, or abrasives.

U-shaped recesses in the sides of the bottom section of the case provide access to the internal operating parts, and permit their removal as a unit, including the bearings of the two shafts, as well as the shifting and belt-tightening screws.

Removal of the lid from the cover section permits minor adjustments, inspection of the internal operating parts, or installation of a new V-belt.

A centralized system lubricates all bearings through force-feed fittings. Rigid copper tubes lead to the four radial shaft bearings, and flexible copper

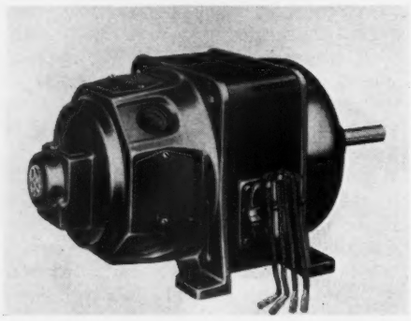
tubes lead to the four thrust bearings fitting around the disk hubs. By means of openings from the thrust bearings, the lubricant is also forced into the spiral grooves of the disk hub bores, thus thoroughly lubricating the disk hubs, shafts, and driving keys.

The cover section accommodates adjustable motor rails and cross rails for mounting complete motor or auxiliary countershaft units. These rails are bolted to each side of the transmission cover, outside the space occupied by the lid of the cover section, leaving the lid accessible for removal. The cross rails for motor mounting are slotted for adjustment, and will permit any design or type of motor suitable to the requirements of the transmission.

The machine is built in 6 sizes up to 10 hp., in all speed ranges. It can be mounted on the floor, ceiling, or in a vertical position.

Robbins & Myers Box-Frame Motors

BOX-FRAME motors, with semi-inclosed end heads, have been announced by Robbins & Myers, Inc., Springfield, Ohio. The motors are available in sizes from ½ to 3 hp., and in repulsion-induction single-phase, polyphase, and d.c. types. Mounting dimensions are identical for all types having similar ratings and speeds. A wool-yarn bearing lubrication system is used. Ball bearings may be supplied if desired.



■

Taylor Compensated Tubing

TAYLOR Instrument Companies, Rochester, N. Y., announce the development of capillary tubing, known as "Tycos" compensated tubing. The announcement states that the volume of mercury in the tubing is so proportioned to its co-efficient of expansion, and to the size of the alloy wire, that any change in the volume of mercury, resulting from variations in external temperature, is accurately compensated.

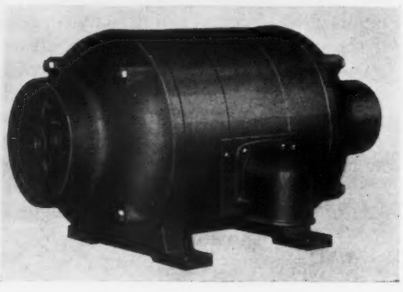
The tubing has an outside diameter of $\frac{7}{32}$ in., welded joints, and a bulb of machined alloy-steel.

■

Burke Inclosed Fan-Cooled Motors

COMPLETELY inclosed motors sealed against dirt, oil, fumes, and moisture, have been announced by the Burke Electric Company, Erie, Pa. A fan cools the motor by forcing the internal warm air through cooling tubes exposed to the reverse blast of outside air, and returning it cooled to the inside of the motor.

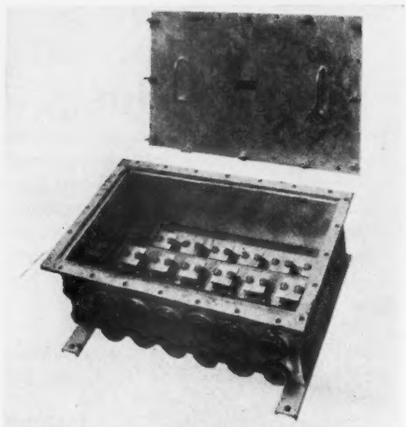
The frame is fabricated from electrically welded bar steel. Stator core laminations are fastened to the cross braces of the frame. All seals are stationary. Mounting dimensions have been made interchangeable with open motors of the same horsepower and rating.



■

Delta-Star Cable Boxes

LOW-VOLTAGE underground cable boxes with type "PB" terminators with mechanical entrances for use with lead-covered cables have been announced by the Delta-Star Electric Company, 2400 Block, Fulton St., Chicago, Ill. The box pictured provides for paralleling six 1,000,000 cm. cables and has one 300,000 cm. tap. It is equipped with disconnecting links and fuses.



■

Goodell-Pratt Merges with Millers Falls Company

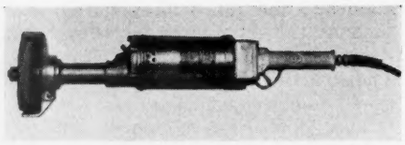
ACCORDING to a recent announcement, The Goodell-Pratt Company, Greenfield, Mass., has merged with The Millers Falls Company, Millers Falls, Mass., which will be the operating company. The two lines of tools will be manufactured under their present trademarks.

■

Standard Portable Grinder and Buffer

ANNOUNCEMENT is made by The Standard Electrical Tool Company, 1938 West 8th St., Cincinnati, Ohio, of a portable electric-driven hand grinder and buffer.

The tool is equipped with a ½-hp., General Electric "Hy-Frequency" motor operating on 220-volt, 180-cycle, 3-phase current. Grinding speed is 5,400 r.p.m. The grinding wheel measures 6 in. in diameter, 1 in. thick, and ⅝ in. in bore. SKF ball bearings run in oil, and are mounted in dust-proof chambers. Four-wire cable is used, one wire being used for a ground. Overall length is 26 in. The tool weighs 20½ pounds.



■

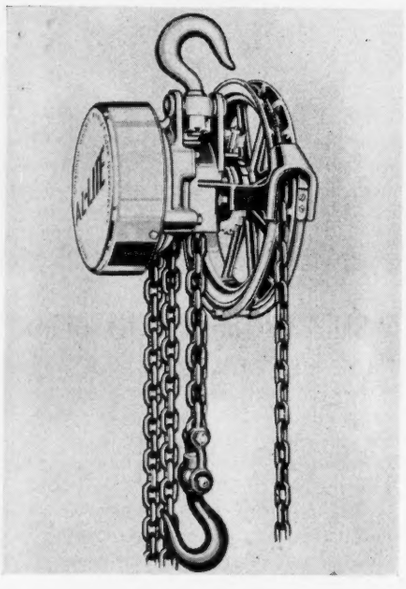
Lincoln Arc-Welding Electrodes

ELECTRODES, known as "Stainweld A," for arc welding corrosion-resisting steel, have been developed by the Lincoln Electric Company, Cleveland, Ohio. The electrodes are extruded and are used with the usual polarity of the welding current reversed. The coating contains no carbon. They are obtainable in $\frac{3}{32}$-, ⅛-, $\frac{5}{32}$-, $\frac{3}{16}$-, and ¼-in. sizes of the regular 11-in. lengths.

■

Chisholm-Moore "Al-Lite" Hoist

ALUMINUM-ALLOY construction features the chain hoist, announced by the Chisholm-Moore Hoist Corporation, Tonawanda, N. Y., known as the "Al-Lite." Alemite lubrication, hardened and ground ball bearings, planetary-type gears, dust-proof housings, adjustable brakes, bright aluminum finish, and "Inswell" chain are other features.



Poor, Inc., "Loadmaster" Cranes

FREDERIC H. Poor, Inc., New York, N. Y., announces a revolving crane, known as the "Loadmaster," for use on crawler tractors. It is used to lift and carry heavy objects in and around industrial plants. The illustration shows the crane mounted on a model GH "Trackson" McCormick-Deering tractor.

The boom is full-revolving and is operated by a power-driven bull wheel equipped with a brake so that the boom may be set at any angle desired. Arrangement is made for controlling the speed of the boom's swing.

The crane has a maximum lifting height of 12 ft. 4 in. under the hook and

a minimum overall height of 8½ ft. when mounted on the tractor. A 10-ft. boom is standard. Special booms for higher lift or longer out-reach may be furnished on order.

■

American Steel and Wire Company Now Makes Preformed Wire Rope

AN announcement recently issued by the American Chain Company, Bridgeport, Conn., states that through the American Cable Company, one of its subsidiaries, it has concluded negotiations with the American Steel and Wire Company, a subsidiary of United States Steel Corporation, to manufacture preformed wire rope under a license agreement. The patents covering this material are owned by the American Cable Company.

This type of wire rope is made by preforming the wires and strands to their helical position in the finished rope. The result, it is claimed, is to bring internal torsional stress to a minimum.

■

General Electric Floodlight

SMALL size distinguishes this 100-watt general-utility projector, known as the "Novalux" handy floodlight, announced by the General Electric Company, Schenectady, N. Y. The unit weighs less than 3 lb., and measures approximately 9 in. wide, 10 in. deep, and 13 in. high together with its supporting stand.

It is built for a 100-watt, inside-frosted, general-service incandescent lamp with a 4⅜-in. light center and medium screw base.

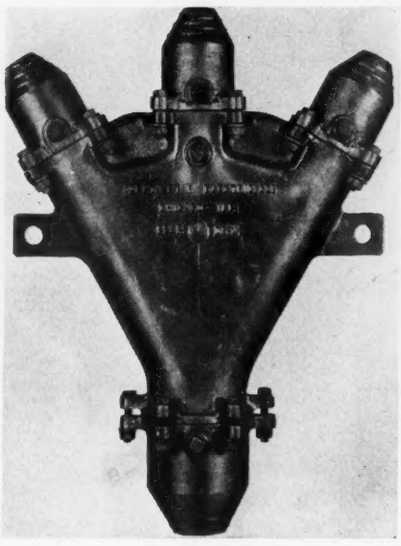
■

Delta-Star "Trifurcators"

DELTA-STAR Electric Company, 2400 Block, Fulton St., Chicago, Ill., announces a compound or oil-filled spreader head known as the "Trifurcator" for use with Type "H" metalized cable.

By its use, the branch lead joint is eliminated and additional support given the cable, as the "Trifurcator" may be equipped with brackets for all mounting requirements.

Wiping sleeves are included in this device.



General Electric "Mazda" Gas-Filled Lamp

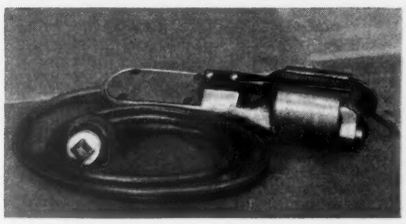
GENERAL Electric Company, Schenectady, N. Y., announces that its 40-watt "Mazda" lamp, formerly made in the vacuum type, has been changed to the gas-filled principle.

According to the announcement, some of the advantages of the gas-filled lamp over its predecessor are: smaller size, less blackening of the bulb, longer life, and whiter light.

■

Chapman Internal Growler

STATORS from fan sizes up to 50 hp. can be tested by the Chapman internal growler, introduced by the P. E. Chapman Electrical Works, 1820 Chou-



teau Ave., St. Louis, Mo. The device will also test armatures. It weighs 3½ lb. and operates from a 60-cycle light socket.

■

Elwell-Parker Telescoping Trucks

TIERING electric trucks fitted with telescopic uprights have been announced by the Elwell-Parker Electric Company, Cleveland, Ohio.

These machines are now available in

sizes up to 6,000 lb. capacity. Maximum lift is 118 in. They will go through a door 7 ft. high x 3½ ft. wide. Some other features are: independent control of brake and power; automatic safety control of travel and hoist motors; automatic elevating; hoist limit cutouts; and fuseless motors for travel, hoisting, tilting, or auxiliary loading and unloading attachments.

TRADE LITERATURE

For copies, address the manufacturers concerned

■

(94) WELDING—Bulletin, 6 pages, second Lincoln arc-welding prize competition.—The Lincoln Electric Company, Cleveland, Ohio.

(95) SWITCHBOARDS — Leaflet GEA-1128A, vertical, steel-panel switchboards.—General Electric Company, Schenectady, N. Y.

(96) INSTRUMENTS — Leaflet 20512, Type A recording voltmeters and ammeters.—Westinghouse Electric & Manufacturing Company, Newark, N. J.

(97) PUMPS—Specification Sheet W-112-S6, 4 pages, Type S.P. horizontal-duplex piston pumps.—Worthington Pump & Machinery Corporation, Harrison, N. J.

(98) WELDER—Folder GEA-1351, automatic, tank and pipe arc welder.—General Electric Company, Schenectady, N. Y.

(99) STEEL PRODUCTS—"Truscon," first edition, 16 pages, a monthly graphic devoted to construction, maintenance, and steel products.—Truscon Steel Company, Youngstown, Ohio.

(100) PIPE-THREADING TOOLS — Catalog, die stocks, reamers, and threaders.—The Oster Manufacturing Company, Cleveland, Ohio.

(101) SWITCH HOUSES—Leaflet GEA-782C, Type SC, GB-4, GB-9, GB-10, and GB-11 outdoor switch houses.—General Electric Company, Schenectady, N. Y.

(102) MATERIALS HANDLING—Graphic, 16 pages, handling and shipping on skids.—The Elwell-Parker Electric Company, Cleveland, Ohio.

(103) FANS—Bulletin 11503, 66 pages, the American H. S. fan, series 30; Bulletin A-101, 82 pages, the Sirocco fan Series 30.—American Blower Corporation, Detroit, Mich.

(104) LIGHTNING ARRESTERS — Booklet 1 of a series, "Crystal Valve" lightning arresters.—Electric Service Supplies Company, 17th and Cambria Sts., Philadelphia, Pa.

(105) KNIFE SWITCHES—Leaflet 20509, Type AL knife switches.—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

(106) INSTRUMENTS — Industrial Control Catalog 5016, 24 pages, circuit breakers, switches and starters.—Condit Electrical Manufacturing Corporation, Hyde Park Station, Boston, Mass.

(107) DIESEL ENGINES — Bulletin S-500-B5, 8 pages, Type B, vertical Diesel engines.—Worthington Pump & Machinery Corporation, Harrison, N. J.

(108) BRAZING EQUIPMENT — Leaflet GEA-1311A, electric brazing equipment.—General Electric Company, Schenectady, N. Y.

(109) STEEL PRODUCTS — Bulletin, 20 pages, "Hallowell" steel work benches and factory equipment. — Standard Pressed Steel Company, Jenkintown, Pa.

(110) CONSTRUCTION EQUIPMENT—Catalog 206, "Rex Champion" paver and road pump.—Chain Belt Company, Milwaukee, Wis.

(111) GENERATORS — Bulletin GEA-820A, 20 pages, vertical water-wheel-driven generators.—General Electric Company, Schenectady, N. Y.

(112) ELECTRIC HOISTS — Bulletin, 8 pages, electric hoists.—Wright Manufacturing Company, Bridgeport, Conn.

(113) THERMOSTATS — Leaflet GEA-311A, Type CR2990-5 a.c. and d.c. thermostats. — General Electric Company, Schenectady, N. Y.

(114) EXCITER SETS — Leaflet 20477, dual-drive exciters.—Westinghouse Electric & Manufacturing Company, South Philadelphia Works, Philadelphia, Pa.

(115) ROTARY CONVERTERS—Leaflet, "Century-Roth" inverted rotary converters.—Roth Brothers & Company, 1400 West Adams St., Chicago, Ill.

(116) PUMPS—Specification Sheet W-112-S9, 4 pages, Type S.P. hot-oil pumps.—Worthington Pump & Machinery Corporation, Harrison, N. J.

(117) SWITCHES — Leaflet GEA-831A, manually operated and solenoid-operated field switches.—General Electric Company, Schenectady, N. Y.

(118) INSTRUMENTS—Catalog, 84 pages, "Tycos" instruments.—Taylor Instrument Companies, Rochester, N. Y.

(119) WELDED STEEL PRODUCTS—Bulletin, 20 pages, Lukenweld construction for machine parts.—Lukenweld, Inc., Coatesville, Pa.

(120) RELAYS—Bulletin GEA-970B, 48 pages, Type PQ plunger-type relays.—General Electric Company, Schenectady, N. Y.

(121) FLOWMETERS — Folder, electric flowmeters.—The Brown Instrument Company, Wayne & Roberts Aves., Philadelphia, Pa.

(122) MOTORS—Folder GES-686, Types BD and CD, d.c. motors.—General Electric Company, Schenectady, N. Y.

(123) WELDING—Bulletin, section 3304, 20 pages, arc welding supplies.—The Lincoln Electric Company, Cleveland, Ohio.

(124) THRUSTORS—Bulletin GEA-1262A, 12 pages, Type CR9504 thrustors.—General Electric Company, Schenectady, N. Y.

(125) GRAPHIC INSTRUMENTS—Leaflet, "The Graphic," No. 231.—The Esterline-Angus Company, Indianapolis, Ind.

(126) MOTORS—Leaflet GEA-1352, Type KG, squirrel-cage induction motors.—General Electric Company, Schenectady, N. Y.

(127) PUMPS — Specification sheet D-423-S9, 4 pages, vertical triplex single-acting power pumps.—Worthington Pump & Machinery Corporation, Harrison, N. J.

(128) SWITCHES—Leaflet, Types F and G, bakelite push-button switches.—Mackworth G. Rees, 983 Milwaukee Ave., East, Detroit, Mich.

(129) ELECTRIC POWER TRANSMISSION—Bulletin 65-C, multiple-conductor terminators. — Delta-Star Electric Company, 2400 Block, Fulton St., Chicago, Ill.

(130) MOTORS—Folder GEA-1368, vertical, hollow-shaft induction motors for deep-well pumping.—General Electric Company, Schenectady, N. Y.

(131) MATERIALS HANDLING—Bulletin, 24 pages, Metzgar end-wood wheels for industrial trucks.—Metzgar Company, Inc., Grand Rapids, Mich.

(132) RESISTOR UNITS—Folder GEA-1363, Type CR9042, form IG, cast-iron resistor units.—General Electric Company, Schenectady, N. Y.

COMING EVENTS

Second National Industrial Congress Featuring Management, Maintenance and Materials Handling—Public Auditorium, Cleveland, Ohio, April 13 to 18, 1931, inc In conjunction, Second National Industrial Equipment Exposition. Concerning technical sessions address P. T. Wetter, American Society of Mechanical Engineers, 29 West 39th St., New York City. Exposition under management Midwestern Engineering Exposition, 308 West Washington St., Chicago, Ill.

American Welding Society — Annual meeting, New York City, Apr. 22-24. Secretary, M. M. Kelly, 33 West 39th St., New York, N. Y.

American Gear Manufacturers Association—15th Annual Meeting, Hotel Statler, Buffalo, N. Y., May 7 to 9, 1931. Secretary, T. W. Owen, 3608 Euclid Ave., Cleveland, Ohio.

National Fire Protection Association—35th annual meeting, Toronto, Can. May 11 to 14, 1931. Association headquarters, 60 Batterymarch St., Boston, Mass.

National Electric Light Association—54th convention and exhibition, Municipal Auditorium, Atlantic City, N. J., June 8 to 12, 1931. Secretary, A. Jackson Marshall, 420 Lexington Ave., New York, N. Y.

Association of Iron and Steel Electrical Engineers—Iron and Steel Exposition, Cleveland Public Auditorium Annex, Cleveland, Ohio, June 14-15, 1931. Managing Director, John F. Kelly, Empire Bldg., Pittsburgh, Pa.

American Society for Testing Materials—Annual meeting, Stevens Hotel, Chicago, Ill., June 22-26. Secretary, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

American Institute of Electrical Engineers — Annual summer convention, Asheville, N. C., June 22-26. Secretary, F. L. Hutchinson, 33 West 39th St., New York, N. Y.

Illuminating Engineering Society—Annual Convention, Hotel William Penn, Pittsburgh, Pa., Oct. 13 to 16, 1931. Assistant Secretary, Frank G. Horton, 29 West 39th St., New York, N. Y.